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THE NICARAGUA CANAL.

By COMMANDER H. C. TAYLOR, U. S. Navy.

[*A paper read at the Stated Meeting of the* FRANKLIN INSTITUTE, *Wednesday, October 15, 1888.*]

(*Continued from Vol. cxxvii, page 47.*)

JOS. M. WILSON, President, in the Chair.

Concerning the traffic which will use the canal it may be divided into the following classes:

	Tons.
(1) Trade across the Isthmus,	1,217,685
(2) Trade between Atlantic and Pacific ports of United States,	145,713
(3) Trade between Atlantic ports of United States and foreign countries west of Cape Horn,	752,585
(4) Trade between Pacific ports of the United States and foreign countries east of Cape Horn,	879,844
(5) Trade around Cape Horn of European countries,	1,471,399
(6) Trade of British Columbia with Europe,	39,818
Total tonnage,	4,507,044

Our Pacific ports are now 13,000 and 14,000 miles away from us by way of Cape Horn. The distances by the canal will be 4,500 to 5,500 miles, and here again we shall gain a great stride upon Europe, and be the nearer to San Francisco by 2,500 miles, instead of being that much further away as we are now. The natural growth and development of these Pacific states and territories will soon furnish thousands of tons of traffic for the canal, for the hundreds that exist under the present conditions. San Francisco owns more ships and a greater tonnage to-day than at any previous time. Portland, Ore., with 40,000 inhabitants, last year handled 12,500,000 pounds of wool and 1,500,000 pounds of hops. Her domestic exports amounted to $9,000,000, and her foreign exports to $5,000,000. Her merchants moved 238,000 tons of wheat and flour, and her grain fleet numbered seventy-three vessels, registering 93,320 tons. The total foreign and coastwise exports from the Puget Sound collection district, last year, amounted to nearly $9,000,000. The salmon canneries of the Northwest coast shipped 1,500,000 cases. The acreage and product of the wheat fields of Eastern Oregon and Eastern Washington have doubled within ten years, and there is enough vacant wheat lands to permit the same phenomenon within the next decade.

The lumber trade of Oregon and Washington presents the most notable development of any line of commerce during the past year. In 1886, the total shipment was 6,000,000 feet. In 1887, it averaged 4,000,000 feet per month, or eight times the total of 1886. There are said to be 20,000 square miles of yellow and red fir alone in Washington, generally known in trade as "Oregon pine," and the trees of these forests reach twelve feet in diameter and 300 feet in height. The timber field of Oregon is a quarter of the superficial area of the state, or 25,000 square miles. The wheat, lumber, fish, wool, furs and other commodities of the Pacific Northwest will be provided to commerce in increasing quantities, and with greater profit to the producers, when cheap water transportation is at hand to convey them promptly to the world's markets.

The trade between Australasia and our Atlantic ports

has quadrupled since 1865, though it is still trifling in comparison with the total foreign commerce of those colonies; but it has grown to what it is without encouragement, and in spite of obstacles and disadvantages, and slight favoring circumstances might open up for us large possibilities in our relations with young English-speaking peoples whose foreign commerce already exceeds $500,000,000 per year. The total tonnage entered and cleared at New Zealand ports in 1885, exclusive of coasters, was 1,032,700, of which a considerable part was by sail with Europe. The distance from Liverpool to Auckland is 500 miles less by Nicaragua than by any other route, and 2,524 miles less than by the Cape of Good Hope. It might very well happen that a part, at least, of this European trade with New Zealand will choose the Nicaragua route, not so much for the distance saved over Cape Horn as for the more favorable weather, winds and currents to be met with in the latitude of the canal. Sailing vessels between Europe and Japan would, by way of Nicaragua, save at least 3,000 miles over other routes.

The stimulus which our domestic and near-by foreign commerce will receive from the safe and sure progress of an inter-oceanic canal towards completion, the natural increase, in six years, of all the classes of trade within the zone of attraction of the canal, and the fair probability of additions from the European traffic by sail with Japan, New Zealand, Fiji and the South Pacific groups, should render it safe to predict a total tonnage of six to six and a half millions for the Nicaragua Canal in 1894. If the cost of constructing the canal should prove to be double the estimate of the engineers, the financial adventure would still be safe and profitable. The commerce which exists to-day assures so much. Half of that commerce is our own. It is wonderful that it should have maintained itself so well in view of the disadvantages under which it has labored.

The greatest traffic of the Suez Canal in 1885 was 8,985,411 tons, in 3,624 vessels. Its present charges are nine francs per ton. While the tonnage and consequently the receipts fell off slightly in the following years, the latest returns show recovery from this slight relapse, and it is safe

to consider 9,000,000 as the present annual tonnage. It must be remembered that this canal opens into the Red Sea, which has always been impossible to sailing ships, on account of the calms. Situated as it is, the Nicaragua Canal route offers every facility for the passage to and departure from the termini of the canal of sailing vessels, for the trade winds are constant for ten months in the year, while for the other two a breeze blows in some direction, generally southwest, giving the vessels dependent on their sails, a constant opportunity to keep themselves under control.

A large portion of the traffic on the Suez Canal is by tramp or freight steamers, to whom economy in coal is of the first importance. Hence, these vessels, though they may return by Suez, will be undoubtedly glad to avail themselves of the favoring trades from Europe to Nicaragua, and again from Nicaragua to the Indies or China and Japan and Australia.

It is safe, therefore, to conclude that a portion at least of the tonnage passing through Suez will find its way to Nicaragua.

Such then are the natural advantages and the general prospects of this enterprise. Let us see what the present company has done to avail itself of nature's favors.

The company has obtained from Nicaragua and Costa Rica concessions of great value. These have been ratified after due consideration by the Congresses of those Republics. The concessions bestow all privileges for this canal, and a railroad and telegraph along its route, as well as land grants amounting to about a million and a quarter acres, most of which is on the canal line. The company has for nearly a year kept a force of 200 men at work in Nicaragua, who have completed the most elaborate and detailed surveys of the location, and have acquired the most intimate acquaintance with the work before it.

Borings along the line of the canal have now been continued for ten months, and the cube to be extracted is intimately known, both in kind and quantity. In addition to this the company has presented the enterprise to the

notice of engineers, business men and capitalists of this country and Europe, in a thorough and impartial manner. It has blinked at nothing, has extenuated or concealed no defect or difficulty. The enterprise is now before the world, depending on its naked merits for approval. In carrying on these surveys and other works, the company has shown its sincerity by expending about $400,000, and this in addition to millions of dollars worth of work done by the United States Government on the same ground in the last twenty years.

The canal can be built and equipped for $60,000,000, but we must organize the final company liberally, and not cramp the enterprise, if unforeseen wars or other complications should intervene to increase its cost. We must be ready to use $100,000,000, if necessary. The traffic ready to use the canal as soon as opened, will give a net revenue of from $12,000,000 to $15,000,000 annually. The final work of the preliminary company is, therefore, to organize the Maritime Canal Company of Nicaragua and Costa Rica, with a capital of $100,000,000. A charter from the United States, though not indispensable, is undoubtedly beneficial, and an act of incorporation was introduced in Congress during the present session. It passed the Senate in February last, and will, it is believed, pass the House of Representatives in December next.

This great enterprise will have results far-reaching and permanent. The commercial world, which has been moving westward since the dawn of history, will be brought by this canal to Philadelphia, New York and New Orleans. The whole circulation in the veins and arteries of trade will be reversed in its direction.

It is a great satisfaction to me to be the humble agent selected to lay this project before so distinguished a society as the FRANKLIN INSTITUTE. I cannot doubt, had Benjamin Franklin lived in these days, that he would have been found in the fore-front of this enterprise, so fraught as it is with profit to our own commerce and industries, and so beneficial to all the dwellers upon earth.

APPENDIX.

[From *Engineering News*, of June 2, 1888.]

THE PROFILE.*

This profile was prepared for the Panama Canal Company, and printed during the current year, for the purpose of showing the work necessary to complete a lock canal. It was afterwards attempted to suppress it, as already noted. It shows, in a very striking manner, the amount of work done upon the Panama Canal during the seven years that it has been under construction, and gives an approximate idea of the amount necessary to complete the canal at sea level; a much more correct idea than it has been possible to form heretofore.

The profile should be considered in the light of M. de Lesseps' repeated declarations that the lock system is only a temporary expedient, and that the company is bound to complete the canal to the sea level, according to its original prospectus. It should also be borne in mind that there is no adequate water supply for the upper lock, 150 feet above the bed of the lowest level; that the problem of controlling the waters of the Chagres River is still unsolved, and that the other elements of doubt and difficulty concerning the lock canal are, if not as many and as great as those which surround the sea-level project, yet very many and very great.

The profile is from the copy referred to by M. Rondeleux in the speech from which we make an extract above.

The first announcement made by the Panama Company of the cube that would remain to be extracted under the lock plan was 40,000,000 cubic metres. In reporting the work done in February, the *Bulletin du Canal Interocéanique*, of May 2d, said: "There remains to extract 32,132,244 cubic metres."

A careful calculation, by scale, of the amount of excavation for the lock canal, as shown on the profile, between kilometres 18 and 67·300, conceding the completion of the two ends (though they are not complete by any means), and taking a slope of one and one-half to one throughout (which cannot be maintained in the higher parts), gives a total of 37,250,627 cubic yards.

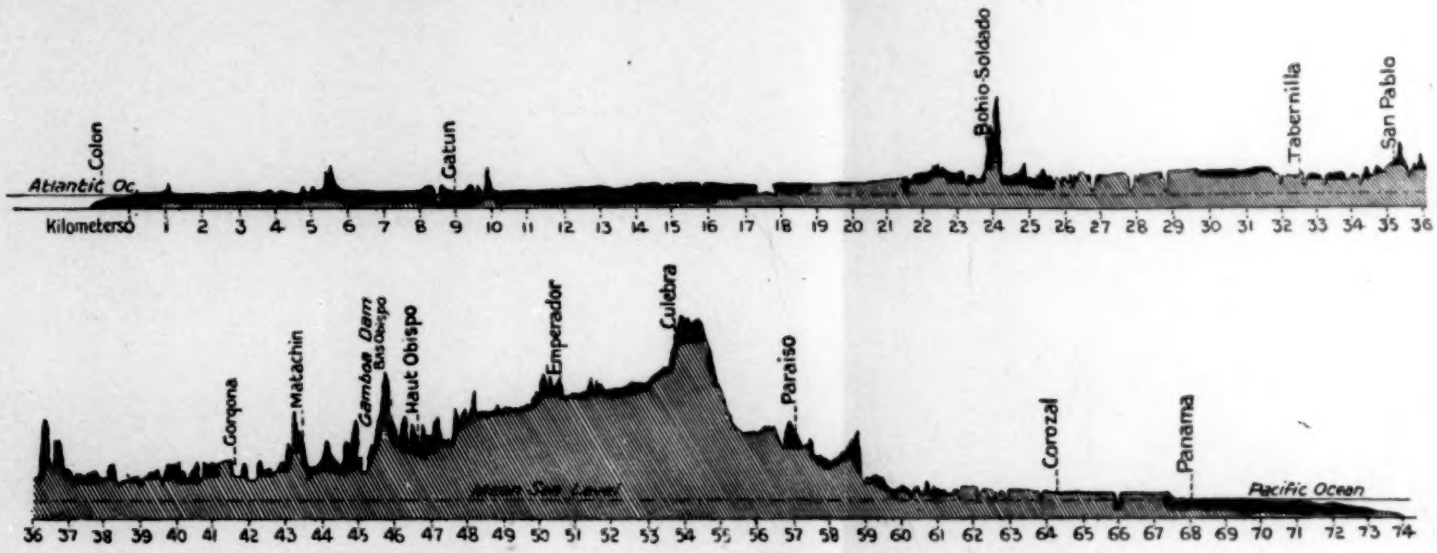
This aggregate amounts to 34,081,086 cubic metres, and takes no account of the work yet to be done in Panama Bay, or in the coral rock between kilometres 67 and 74, and without the channels for the deflection of the Chagres, the Rio Grande and the Obispo, amounting certainly to several millions of cubic metres.

The excavations for the locks will also be considerable in quantity, and it will be strange if they are not likewise of a difficult and tedious nature, since the locks are located in rock. It therefore appears far within the proabilities to place the total excavation remaining to be accomplished for the canal, with ten locks, at 50,000,000 cubic metres. If the upper locks be abandoned, as contemplated by the terms of the Eiffel contract, it will add largely to the cube and the difficulty.

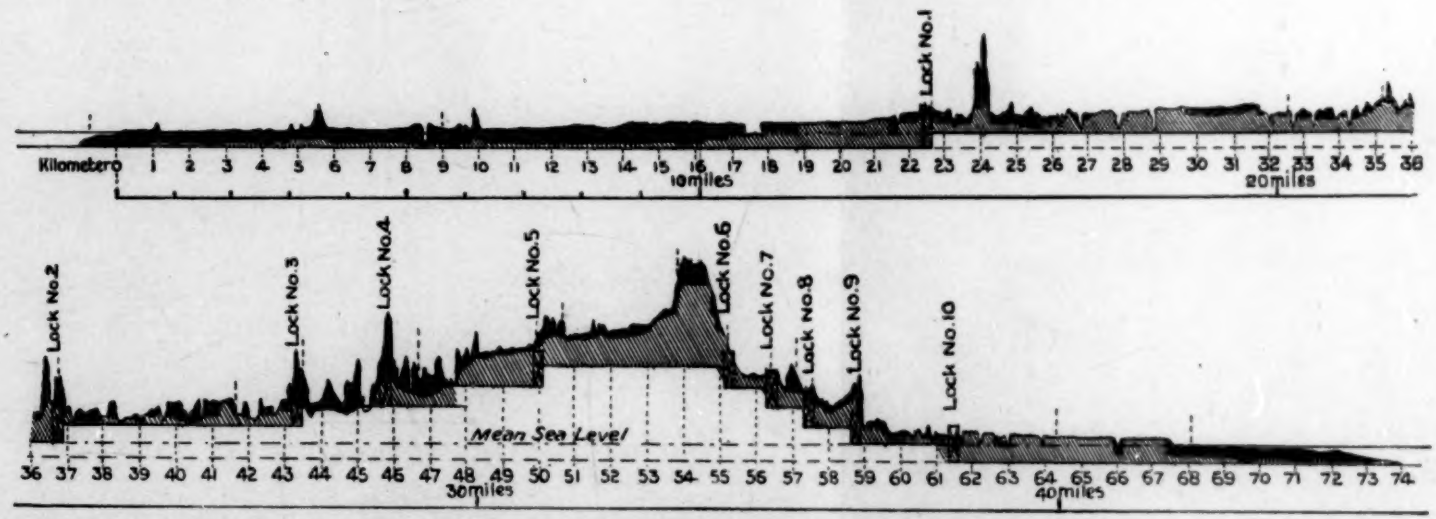
* For the use of this illustration we are indebted to *Engineering News*. (W.)

PROGRESS PROFILE OF THE PANAMA CANAL.

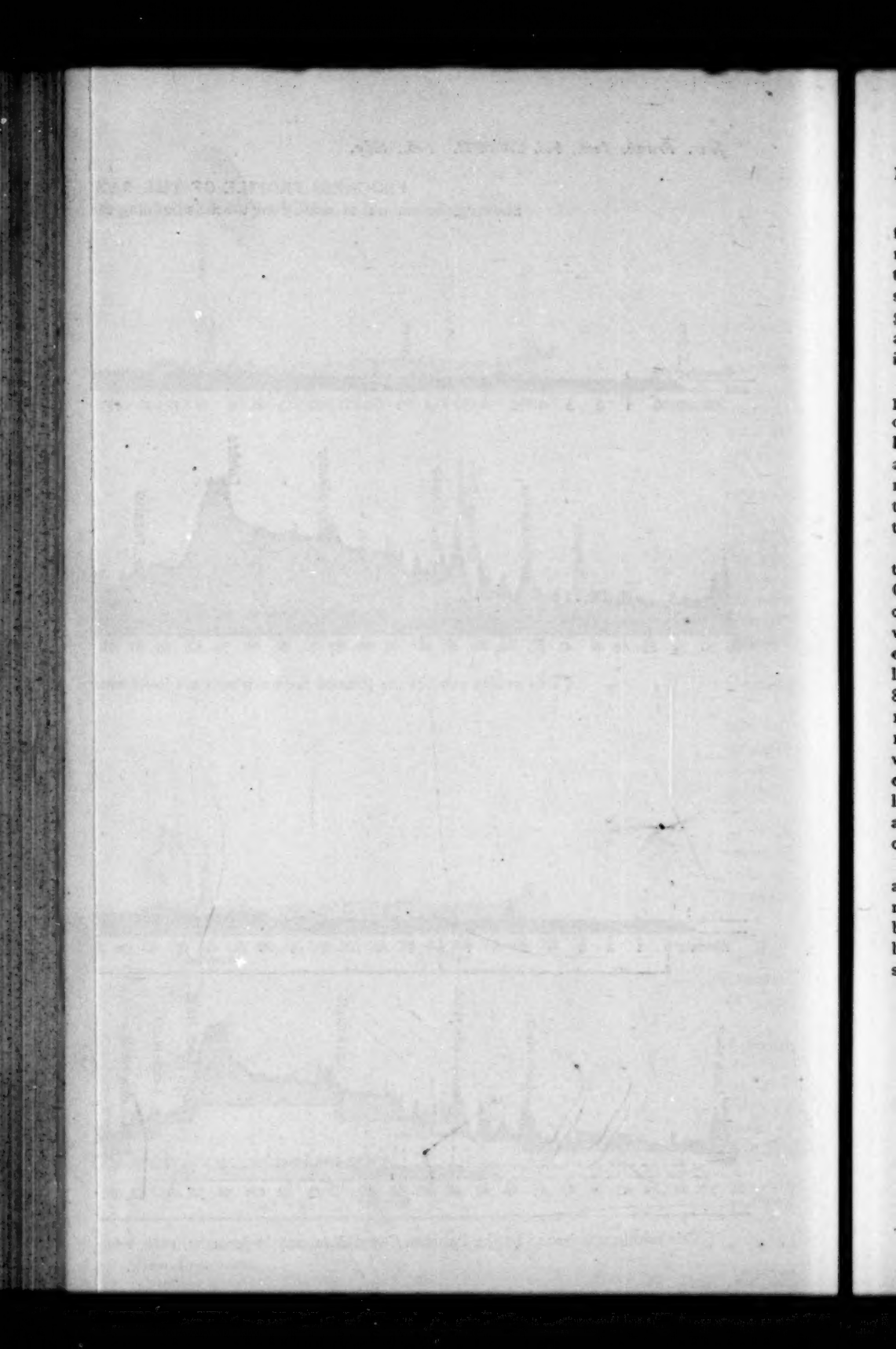
Showing the amount of work done towards building the canal, up to January 1, 1888.


Colon
Atlantic Oc.
Gatun
Bohio-Soldado
Tabernilla
San Pablo
Kilometers 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Gorgona
Matachin
Gamboa Dam
Bas Obispo
Haut Obispo
Emperador
Culebra
Paraiso
Corozal
Panama
Mean Sea Level
Pacific Ocean
36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74

[This profile exhibits the state of the work as a sea-level canal—when this plan was abandoned.]



[This profile was issued by the Panama Canal Company in January, 1888, primarily to show the lock system, and the small remaining amount of work.



Now the company's rate of excavation, even with the help of the large figures from the Colon-Gatun section, has not averaged 1,000,000 cubic metres per month, the past two years through. At the best rate of progress, therefore, and with the most liberal allowances, there is work enough to consume four years, and that would involve the disbursement of something like $80,000,000 for interest and sinking fund of the debt and expenses of administration, without counting a dollar for work or material on the canal itself.

Though the work accomplished thus far has been the easiest that the line presents, still, more than one contractor has succumbed before the difficulties of the Culebra. Some of the richest and most experienced firms of Europe have declared the tasks of that portion of the line beyond their power to accomplish, and have abandoned their contracts. The laborers are not more numerous nor more efficient than they were when Señor Tanco Armero declared that the results of their work convinced him that there had never been more than 5,000 men employed, though the company claimed to have 15,000.

Again, the water for the supply of the lock system, so far as is known, is to be furnished from the Chagres River. In the dry season the flow of the Chagres is at the rate of ten cubic metres per second, of the Obispo one cubic metre, and of the Rio Grande 0·4 cubic metre. The three streams would therefore supply some 259,977,600 gallons per day. The capacity of each of the locks is 40,000 cubic metres, and each vessel crossing the summit level will require the two locks to be emptied once, using something like 80,000 cubic metres of water. The Panama Company claims a tonnage of 10,000,000 per year, or 28,000 tons per day, representing twenty vessels of 1,400 tons each, although this seems to us a most exaggerated estimate. The water required for their transit would be 322,400,000 gallons per day. The evaporation and filtration, estimated at one per cent. per day, would entail a loss of something like 47,300,000 gallons, making the daily requirement amount to 369,709,000 gallons. The supply is 259,977,600, and the shortage on this basis 109,765,260 gallons.

We should hardly expect from this computation that there would really be any shortage of water supply, since we have no belief that the traffic will reach 10,000,000 tons, or anything approaching it, for a long period of years, but it seems to be admitted that pumping will be necessary, and it seems to be proposed to provide for it. Therefore, we apprehend that this water supply estimate is really too liberal.

APPENDIX.—Tables covering twelve months from July 1886, to June, 1887, inclusive.

RIVAS—JULY, 1886. LAT. 11° 26′ N.; LONG., 85° 49′ W. 7 A.M., WASHINGTON TIME; 6·17 A.M., LOCAL TIME. BAR.—150 FEET ABOVE SEA LEVEL.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·90	77	80	NE	0	. . .	Clear
2	·90	77	80	SE	1	1·0	Cloudy
3	·90	75	82	NW	0	2·8	"
4	·92	78	80	N	1	. . .	Clear
5	·90	77	80	NE	0	. . .	"
6	·90	75	82	N	0	4·7	Cloudy
7	·90	74	82	SE	0	1·1	"
8	·90	75	82	"	0	. . .	Clear
9	·92	75	82	"	1	3·	Cloudy
10	·90	73	82	"	1	2·2	Clear
11	·90	75	82	"	0	. . .	"
12	·90	75	80	NE	0	. . .	"
13	·90	77	80	E	1	. . .	"
14	·90	74	80	SW	0	1·4	Cloudy
15	·90	75	82	"	2	6·	"
16	·92	74	82	"	1	3·3	"
17	·90	73	82	"	0	·2	Clear
18	·92	76	82	NE	1	. . .	"
19	·92	75	80	SE	0	. . .	"
20	·90	75	80	"	0	. . .	"
21	·90	77	80	NE	1	. . .	"
22	·90	77	82	"	0	1·7	Cloudy
23	·90	76	80	"	0	2·2	"
24	·90	77	80	E	0	. . .	Clear
25	·90	77	80	"	0	. . .	"
26	·90	76	80	"	1	·5	Cloudy
27	·90	76	80	N	1	·4	"
28	·90	77	80	E	1	·0	Clear
29	·90	77	80	S	2	·1	"
30	·90	73	82	SE	0	2·1	"
31	·90	73	82	E	0	4·6	"
			80·9			cm. 38·2 inches. = 15·09	

AUGUST, 1886.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·90	73	80	E	1	. . .	Clear
2	·90	75	80	NE	0	·6	"
3	·90	76	82	"	1	·5	Cloudy
4	·90	76	80	N	0	·4	Clear
5	·90	75	82	"	0	4·6	Cloudy
6	·90	75	82	"	1	·4	"
7	·91	75	82	"	1	1·8	"
8	·92	74	82	SE	1	1·1	"
9	·90	74	82	"	0	3·4	"
10	·90	74	82	"	1	4·5	"
11	·90	76	82	E	0	·6	Clear
12	·90	77	80	"	1	·1	"
13	·90	75	80	N	0	·2	"
14	·90	74	80	W	1	·6	"
15	·90	74	82	NE	1	1·4	Cloudy
16	·90	75	82	SE	1	1·9	"
17	·90	75	80	SW	0	·4	"
18	·90	74	80	W	1	·5	"
19	·90	73	82	"	1	·6	"
20	·90	74	82	SW	0	5·1	Clear
21	·90	74	80	SE	1	. . .	"
22	·90	76	82	SW	0	·4	Cloudy
23	·90	74	82	"	0	4·9	"
24	·92	74	80	S	1	. . .	Clear
25	·90	73	82	SW	0	2·5	Cloudy
26	·90	74	82	E	0	2·5	Clear
27	·90	74	82	SE	0	. . .	Cloudy
28	·90	74	82	"	0	2·6	"
29	·90	74	82	"	0	1·	"
30	·90	75	82	S	1	1·1	"
31	·90	74	82	NE	0	·3½	"
			87·3			cm. 44·05 inches. = 17·40	

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·93	·74	80	S	0	. . .	Cloudy*
2	·92	78	82	NE	1	. . .	Fair
3	·92	72	82	NW	1	. . .	Cloudy
4	·92	74	80	"	1	. . .	Fair
5	·90	76	78	NE	1	. . .	"
6	·90	75	78	SW	0	1·30	"
7	·91	74	78	S	0	·74	"
8	·90	75	80	SE	0	·18	Cloudy*
9	·90	74	81	E	0	·55	Fair*
10	·90	74	82	SE	0	·74	Cloudy
11	·92	77	80	E	1	·11	"
12	·92	77	80	"	1	. . .	Cloudy†
13	·90	74	81	SE	1	·35	"
14	·93	73	82	SW	2	1·70	"
15	·93	73	82	SE	0	1·10	"
16	·93	73·5	82	"	0	2·24	"
17	·91	73	83	NW	1	2·26	"
18	·91	74	82	"	1	. . .	"
19	·92	74·5	80	W	1	·02	Fair
20	·93	74·5	80	NW	0	. . .	Cloudy
21	·89	76	83	"	0	. . .	"
22	·89	76	81	"	1	·12	"
23	·92	73·5	82	S	0	·67	Clear
24	·91	76	80	SW	1	·55	Fair‡
25	·93	73	81	NW	0	·52	"
26	·92	74·5	82	W	0	·90	Cloudy
27	·90	76	81	SE	0	. . .	Cloudy§
28	·89	72	82	NW	0	·95	Clear
29	·92	75	82	E	0	·25	Fair
30	·94	75	83	SW	0	·05	Cloudy
			81			cm. 15·30 inches. = 6·04	

SEPTEMBER, 1886.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·93	74	80	SW	0	. . .	Fair
2	·92	73·5	81	SE	0	·27	Clear
3	·93	74	83	NW	0	1·14	Fair
4	·90	75	82	SW	0	·40	Cloudy
5	·94	73	80	NW	0	·08	"
6	·90	74	82	"	0	1·37	"
7	·92	75·5	82	"	2	·63	"
8	·94	76	82	W	2	1·10	"
9	·92	74·5	80	S	1	·80	Fair
10	·93	75	82	"	1	·02	"
11	·93	75	80	SW	1	. . .	Cloudy
12	·95	73·5	82	"	0	·35	"
13	·95	75	80	"	0	·04	Clear
14	·92	76·5	80	NE	0	·04	Cloudy
15	·93	76	81	"	0	·77	"
16	·94	75	78	"	1	·04	Clear
17	·92	76	80	"	1	. . .	"
18	·92	75	80	"	1	. . .	Cloudy
19	·90	72·5	81	"	1	·13	Fair
20	·90	72·5	80	"	0	·31	Clear
21	·90	72·5	78	"	0	·0	"
22	·90	72·5	77	NW	1	·10	Cloudy
23	·90	74	78	"	0	. . .	Clear
24	·92	74	78	"	0	·5	"
25	·93	71	77	E	1	·14	"
26	·93	75	79	"	0	. . .	"
27	·92	76	78	"	0	. . .	"
28	·88	75	76	"	0	. . .	Cloudy
29	·90	76	80	"	0	·13	"
30	·92	76	77	"	1	. . .	"
31	·90	76	77	"	0	·13	Fair
			79·7			cm. 10·85 inches. = 4·28	

OCTOBER, 1886.

* Smoky.

† Column of smoke from volcano near by. Rumbling from same.

‡ Thunder-shower.

§ Heavy thunder-shower S.E.

NOVEMBER, 1886.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·92	77	77	E	1	. . .	Cloudy
2	·90	74	80	NW	1	·27	Clear
3	·92	76	80	E	0	·35	Fair
4	·95	76	78	"	0	. . .	"
5	·93	76	79	"	1	·76	Cloudy
6	·90	75	76	NE	2	·98	Clear
7	·90	73	76	E	0	. . .	"
8	·92	75	75	NE	2	. . .	"
9	·92	74	76	"	1	·02	"
10	·92	77	76	"	2	. . .	Fair
11	·92	75	77	"	1	. . .	Clear
12	·90	76	79	"	0	. . .	Cloudy
13	·90	75	82	"	0	·07	"
14	·93	76	80	"	0	·02	"
15	·92	77	79	E	1	·04	Fair
16	·92	77	78	"	1	·86	"
17	·90	77	79	NE	1	·04	Cloudy
18	·91	76½	78	"	2	·06	Fair
19	·94	77	78	"	2	·19	Cloudy
20	·92	76	78	E	2	. . .	Fair
21	·90	76	76	"	2	·02	"
22	·92	76	78	NE	1	·02	"
23	·90	75½	80	"	1	·17	Clear
24	·90	74	80	"	0	·33	Fair
25	·91	73	79	SE	0	. . .	Clear
26	·93	75	80	E	1	·02	Cloudy
27	·92	74	78	NE	1	·43	"
28	·92	72	80	"	1	. . .	Clear
29	·92	74	77	"	1	. . .	"
30	·92	74	76	E	1	. . .	"
	29·916		78·1			cm. 3·75 inches. = 1·48	

DECEMBER, 1886.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·92	74	77	NE	1	. . .	Fair
2	·93	74	78	"	2	. . .	Clear
3	·92	74	78	"	2	. . .	"
4	·91	74	77	"	2	. . .	"
5	·92	74	78	"	1	. . .	"
6	·92	75	74	"	2	. . .	"
7	·92	71·5	70	"	3	. . .	"
8	·92	73	73	E	2	. . .	"
9	·92	74	77	ENE	1	. . .	Cloudy
10	·92	74	78	"	1	. . .	Clear
11	·92	75	78	NE	2	. . .	Fair
12	·92	77	77	ENE	1	. . .	"
13	·92	76	77	NE	2	. . .	"
14	·92	75	78	"	3	. . .	"
15	·92	73	78	"	0	. . .	Cloudy
16	·92	73	78	"	3	. . .	Clear
17	·92	74	74	"	3	. . .	"
18	·92	75	79	"	2	. . .	"
19	·92	74	78	"	1	. . .	"
20	·92	74	78	"	1	. . .	"
21	·92	74	77	"	2	·47	"
22	·94	76	78	"	1	. . .	"
23	·93	76	77	"	2	. . .	"
24	·92	75	78	"	1	. . .	"
25	·92	74	77	"	1	. . .	"
26	·93	74	78	"	1	. . .	"
27	·92	75	78	"	1	. . .	"
28	·92	75	79	"	1	. . .	"
29	·93	74	79	"	1	. . .	"
30	·92	74	77	"	1	. . .	"
31	·90	72	80	"	0	·02	"
	29·921		77·1			cm. ·49 inches. = ·19	

JANUARY, 1887.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·92	70	80	E	0	. . .	Clear
2	·94	75	79	NE	3	. . .	"
3	·92	72	70	"	3	. . .	"
4	·93	72·5	72	E	2	. . .	Cloudy
5	·92	71	75	ENE	2	. . .	Fair
6	·92	73	70	E	1	. . .	Cloudy
7	·92	74	79	NE	2	. . .	Fair
8	·91	75	79	E	1	. . .	Cloudy
9	·91	75	76	NE	2	. . .	Clear
10	·92	75	79	"	1	. . .	Fair
11	·93	77	78	"	2	. . .	Cloudy
12	·92	73	78	"	1	·50	"
13	·93	73	80	"	1	·10	Clear
14	·93	73·5	78	E	1	·02	Fair
15	·93	74	78	"	2	. . .	Clear
16	·93	74	78	NE	3	. . .	Cloudy
17	·93	73	79	E	1	·13	"
18	·95	73	74	"	2	. . .	Clear
19	·93	73	73	ENE	3	. . .	"
20	·93	73	80	"	3	. . .	"
21	·93	74·5	76	"	2	. . .	"
22	·92	74	78	"	3	·10	Cloudy
23	·92	74	78	E	2	. . .	Clear
24	·92	74·5	79	"	1	. . .	"
25	·92	73	77	"	2	·02	"
26	·92	73·5	79	ENE	3	. . .	"
27	·92	74	77	NE	3	. . .	"
28	·93	73·5	77	ENE	4	. . .	"
29	·93	73·6	81	NE	3	·03	Fair
30	·92	75·2	78	E	1	. . .	"
31	·92	74	78	NE	3	. . .	Clear
			77·1			cm. ·90 inches. = ·35	

FEBRUARY, 1887.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	29·92	75	78	E	3		Clear
2	·92	73	80	"	2	·33	Cloudy
3	·91	73·5	79	"	2	·15	Fair
4	·89	74	79	"	2	·08	"
5	·90	74	78	"	3	·05	Cloudy
6	·92	74	80	"	2	·08	"
7	·93	74	78	NE	2	. . .	Clear
8	·92	75	77	"	3	·08	"
9	·93	73	76	"	3	. . .	"
10	·93	74	75	"	3	. . .	Fair
11	·93	73	78	E	1	. . .	Clear
12	·90	74·5	78	"	4	. . .	"
13	·92	73	74	"	4	. . .	"
14	·93	74	76	"	3	. . .	"
15	·93	74	78	"	3	. . .	Cloudy
16	·92	74	80	ENE	2	·04	Clear
17	·92	73	78	"	1	. . .	Fair
18	·93	73	78	"	—	. . .	Clear
19	·92	74	78	E	1	. . .	"
20	·91	75	78	"	1	. . .	"
21	·92	74	78	"	1	. . .	Cloudy
22	·93	74	76	"	1	. . .	Fair
23	·93	73	79	"	1	. . .	"
24	·93	74	78	"	2	. . .	"
25	·92	76	76	"	2	. . .	"
26	·91	75	77	"	2	. . .	Clear
27	·92	74	78	"	2	. . .	"
28	·92	74	78	NE	3	. . .	Cloudy
			77·6			cm .81 inches. = ·32	

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
March, 1887.							
1	29·94	74	76	E	5		Clear
2	·94	74	76	"	3		Fair
3	·93	74	77	"	3		Clear
4	·93	74	76	ENE	4		"
5	·93	73·5	77	E	3		"
6	·92	74	75	"	2		"
7	·93	73	78	"	1		"
8	·93	72·5	78	"	1		"
9	·93	73	78	ENE	1		"
10	·93	73	78	"	1		"
11	·93	73	78	"	2		"
12	·93	73·5	78	"	1		"
13	·93	74	76	E	1		"
14	·93	75	78	"	2		"
15	·93	74·5	75	E x N	3	None.	Cloudy
16	·92	73	75	E	1		Clear
17	·92	74	75	ENE	1		"
18	·92	74	77	E	2		"
19	·92	73	75	ENE	2		"
20	·92	73	77	"	2		"
21	·92	73	77	E	1		"
22	·92	74	78	"	2		"
23	·92	75	78	"	1		"
24	·92	75	78	"	1		"
25	·92	75	78	"	1		"
26	·92	74	78	"	2		"
27	·92	74	78	"	3		Fair
28	·88	74	77	"	2		Clear
29	·90	74	78	"	1		"
30	·90	75	78	"	2		Cloudy
31	·90	75	78	"	2		Clear
		77·9					

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
April, 1887.							
1	29·90	74·5	78	E	1		
2	·90	74·8	78	"	2		
3	·93	75	78	"	2		
4	·92	75·2	79	ENE	3		
5	·94	75	78	"	2		
6	·93	75	78	E	2		
7	·92	76	78	"	3		
8	·93	76	78	ENE	2		
9	·92	76	78	E	1		
10	·92	76	77	"	2		
11	·90	76	77	"	1		
12	·93	77	77	ENE	1		
13	·92	77	78	E x S	1		
14	·93	77	80	E	1		
15	·90	77·5	78	"	1		
16	·91	77·5	78	"	1		
17	·90	77	79	"	1		
18	·89	77·5	79	"	1		
19	·89	77	77	ENE	1		
20	·90	78	78	E	1	None.	
21	·90	78	78	"	1		
22	·90	77	78	ENE	2		
23	·90	76·8	77	E	2		
24	·89	78	78	"	1		
25	·87	77	79	"	1		
26	·90	77	78	ENE	1		
27	·93	77	78	"	3		
28	·93	77	78	E	3		
29	. . .	77	76	NE	2		
30	. . .	78	78	E	1		
			77·9				

Winds through January and February increased in force about 10 A M.

MAY, 1887.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
						cm.	
1	. . .	78	78	E	2	. . .	Clear
2	. . .	78	78	NE	2	. . .	"
3	. . .	76	77	"	1	. . .	"
4	. . .	76	78	E	2	. . .	"
5	. . .	78	78	"	2	. . .	"
6	29·92	78	78	NE	2	. . .	"
7	·93	78	80	E	1	. . .	Fair
8	·90	78	78	"	1	. . .	Cloudy
9	·92	78	79	N	1	. . .	"
10	·90	78	79	NE	1	. . .	"
11	·92	75	80	E	1	. . .	"
12	·86	77	88	NE	1	. . .	Fair
13	·86	75	89	W	1	. . .	Clear
14	·88	79	82	NE	0	·02	Cloudy
15	·90	74	80	"	1	1·41	Fair
16	·92	76	80	W	1	1·31	Cloudy
17	·87	76	80	"	0	·27	"
18	·90	75	80	"	0	·67	Fair
19	·90	73	80	S	1	4·09	Cloudy
20	·93	73	80	"	1	·59	Fair
21	·97	74	80	W	1	·19	"
22	·98	75	80	"	0	·15	"
23	. . .	75	80	SE	1	·28	"
24	. . .	74	80	"	0	. . .	Cloudy
25	. . .	77	80	"	1	·04	"
26	. . .	78	79	E	1	. . .	"
27	. . .	77	79	"	1	·35	"
28	. . .	75	79	SE	2	. . .	Fair
29	. . .	77	79	E	2	. . .	Cloudy
30	. . .	77	79	"	1	. . .	"
31	. . .	78	79	"	1	. . .	"
			79·9			cm. 9·17 inches. = 3·62	

JUNE, 1887.

Day.	Bar.	Dry Bulb.	Relative Humidity.	Wind. Direction.	Wind. Force.	Rainfall in Twenty-four Hours.	State of Weather.
1		78	79	E	1	. . .	Fair
2		77	79	"	1	. . .	Cloudy
3		78	79	"	0	·15	"
4		75	79	NE	1	. . .	Fair
5		77	80	W	0	. . .	Cloudy
6		78	80	E	1	·31	"
7		77	80	"	0	·78	"
8		76	80	N	0	. . .	"
9		75	80	E	1	. . .	Fair
10		76	80	"	1	·08	Cloudy
11		75	80	W	0	1·26	"
12		75	80	"	0	. . .	Fair
13		73	80	"	0	. . .	"
14		76	80	"	0	. . .	Cloudy
15		75	80	"	0	. . .	Clear
16		76	80	"	0	·43	"
17		74	81	"	0	·16	Cloudy
18	None.	75	80	"	0	·13	Fair
19		76	80	"	0	·58	Cloudy
20		74	81	"	0	·50	"
21		75	80	"	1	·44	Clear
22		75	80	"	1	·08	Cloudy
23		74	80	"	1	·40	Fair
24		74	80	E	1	·16	Clear
25		74	81	SE	1	2·56	Cloudy
26		75	80	E	0	·16	Fair
27		77	80	SE	4	. . .	Clear
28		77	80	NE	1	. . .	"
29		77	80	"	1	. . .	"
30		77	80	E	0	. . .	Cloudy
			79·9			cm. 8·18 inches. = 3·23	

Mean humidity for year, 78·9.

Rainfall for year, 131·70 cm. = 52·00 inches.

In order to test the capacity of the canal as regards its facility for navigation, let us compare it with the Suez Canal, whose financial success is already well established. The Suez Canal is 100 miles long, with a continuous depth of twenty-six feet, and a uniform bottom width of seventy-two feet.*

The width of surface water varies from 190 to 330 feet, according to the slope required by the soil.

"The area of water prism ranges, therefore, between a minimum of 3,406 square feet and a maximum of 5,226 square feet. The minimum radius of curve is 2,000 feet. Its entire length is open to ships of all nationalities, provided their draught does not exceed 7·51 metres (24′ 7″).

"The maximum speed of all ships passing through the canal is fixed at ten kilometres (equal to 5⅖ nautical miles or 6$\frac{1}{10}$ statute miles) per hour. (From regulations for navigation of Suez Canal).

"Vexatious delays, due to grounding in rounding the sharp curves and in going in and out of the sidings to allow other vessels to pass and stoppages for the night, make the time of vessels in the canal range from forty to seventy hours.

"However, the average effective sailing speed, as given in the reports of the company, is five knots an hour. The passage has been made in fifteen hours by starting at break of day and getting through before dark."

At Suez the traffic has been seriously delayed by the dimensions of the canal and the inadequate number of turnouts.

In the present project not only have enlarged prisms been provided for, but large basins are proposed at the extremities of the locks. These basins, the enlargement of the canal at each end, with the lake, the river and the San Francisco Basin, will permit vessels to pass each other without delay at almost every point on the route.

In 21·0 miles or 72·9 per cent. of the canal in excavation, the prism is large enough for vessels in transit to pass each other, and of a minimum sectional area of 4,500 square feet.* The remaining distances in which large vessels cannot conveniently pass each other are so divided that the longer is only 4·73 miles in length and the shorter 3·07 miles. These short reaches of narrow canal are situated between basins, and can be traversed by any vessel in the same or less time than is estimated for the passage of a lock; consequently unless a double system of locks be constructed nothing will be gained by an enlargement of the prisms.

The possible detention in the transit, due to those narrow cuts, which should not in any case exceed forty-five minutes, would not justify the necessary increase of expense involved in an enlargement of the cross-section proposed. Both the bottom width and the depth of the proposed canal are larger than those of the Suez Canal.

"In the lake and in the largest portion of the San Juan River vessels can travel almost as fast as at sea. In some sections of the river, and possibly in the basin of the San Francisco, although the channel is at all points deep and

* The sectional area of the North Sea and Baltic Canal, inaugurated June 3, 1887, is 3,934 square feet, and will permit the passing of ordinary ships at any point.

of considerable width, the speed may be somewhat checked by reason of the curves.

ESTIMATED TIME OF THROUGH TRANSIT BY STEAMERS.

	Hours.	*Minutes.*
28·89 miles of canal at five miles an hour, ...	5	46
20·28 miles in the San Francisco, Machado, Deseado and La Flor basins, at eight miles an hour, . . .	2	32
64 miles in the San Juan River at nine miles per hour,	7	6
56·50 miles in the lake at ten miles an hour, . . .	5	39
Time allowed for passing six locks at thirty minutes each, ...	3	
Allow for detention in narrow cuts, ...	1	30
	25	24

"The experience of the Suez Canal shows that the actual time of transit is more likely to fall under than to exceed the above estimate.

"The traffic of the canal is limited by the time required to pass a lock, and on the basis of thirty-five minutes (above estimated) and allowing but one vessel to each lockage, the number of vessels that can pass the canal in one day will be forty-eight, or in one year 17,520, which, at the average net tonnage of vessels passing the Suez Canal (2479·4 for 1885), will give, as the annual capacity of the canal, 43,422,088 tons. This is on the basis that the navigation will not be stopped during the night.

"With abundant water-power at the several locks and the dam, there is no reason why the whole canal should not be sufficiently illuminated by electric lights; and with beacons and range lights in the river and lake, vessels can travel at all times with perfect safety."

In preparing this paper, the writer has not hesitated to draw upon the writings of many gentlemen, as sources of information; as regards engineering features, he is indebted to United States Civil Engineers Menocal and Peary, and to Mr. J. C. Hueston of the Nicaraugua Canal office.

[At the close of Commander Taylor's remarks, the thanks of the meeting were tendered to him for his able and interesting presentation of this important subject.]

SPIRALLY WELDED STEEL TUBES.

By J. C. Bayles.

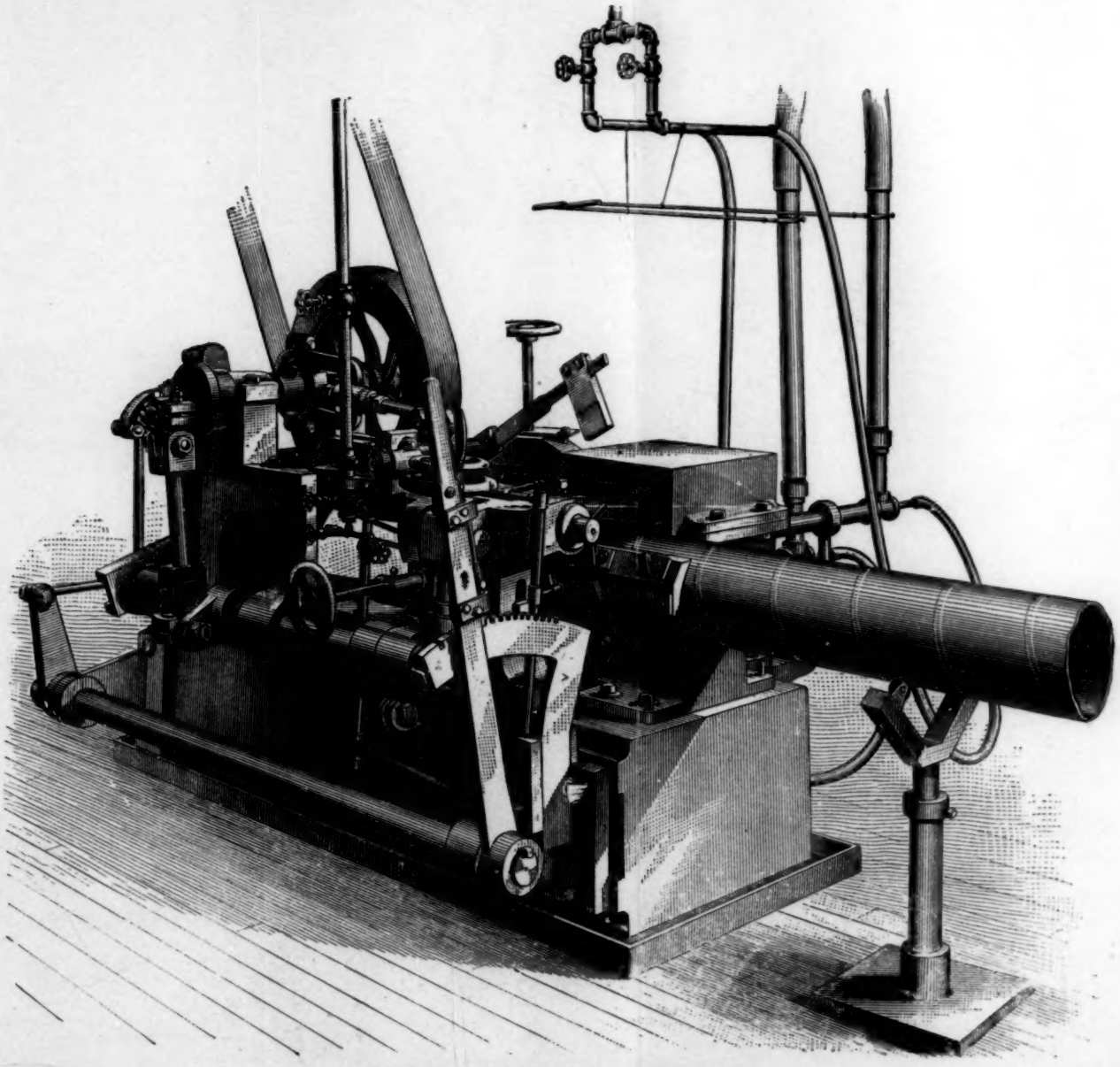
[*An abstract of remarks made at the meeting of the* Institute, *held Wednesday, January 16, 1889.*]

Joseph M. Wilson, President, in the Chair.

Mr. Bayles:—Mr. President and Members of the Institute:

The manufacture of light steel pressure pipes made from strips of metal wound laterally and hammer-welded, is an entirely new industry, employing means and producing results wholly unlike any before known in the arts.

In iron and steel pipe, it is desirable to use no more material than is needed to give the strength desired. This is true of all products, the progress of the arts tending steadily to a good constructive use of material, to secure a maximum of strength with a minimum of dead weight. As the rule, lap-welded tubes are enormously heavier than anything in the service to which they are subjected, warrants. They are made so for no other reason than that lighter stock than that employed in making them cannot be used. If the stock is heated in sheets, drawn from the furnaces at the welding temperature, shaped on a mandrel and welded, a considerable body of stock is needed to hold the heat during the shaping and welding processes. With thin sheets one of two things would happen: either the metal would chill instantly when drawn from the furnace, and refuse to weld; or, if hot enough, would collapse upon itself, defeating all efforts to shape and weld it. Light pipes would have been made by lap welding long ago had it been possible. As it is, they are much heavier than their strength calls for, the longitudinal weld being, as the rule, a line of weakness. In spirally welded pipes we have the material used to the very best advantage. The weld,



Machine for Making Spiral-Weld Tubes.

instead of being a line of weakness, is a spiral reënforcement. A circumferential twisting strain is not created transversely to the weld, but longitudinally; or, to be more accurate, obliquely; and such pressure does not tend to open the seam, as in the case of a longitudinal weld, but to close it. The behavior of a spirally-welded pipe under pressure is illustrated by a very simple experiment. Roll a ribbon of paper into a spiral tube, as children make lamplighters, pinch one end tightly shut and blow in the other. It will be found that the first effect of internal pressure is to tighten the seams, and the paper may be burst before any air will leak out between the edges of the parts in contact. I have seen a defective spirally-welded pipe leak under twenty pounds pressure, become tight at fifty pounds, and remain tight up to 350 pounds per square inch. Under an internal bursting strain, the strength of a spirally-welded tube is found in the testing machine to be as great as the theoretical strength of the stock.

The process of manufacture is simple and inexpensive, but has entailed many and serious difficulties. These, however, have been overcome. Steel of suitable quality, *i. e.*, weldable, and having a tensile strength of 65,000 pounds per square inch, with about fifty per cent. reduction of area and fifteen to eighteen per cent. elongation, is rolled in grooves to the proper width, and as long as may be convenient. These strips are welded end to end in a machine built for the purpose, which works very well. As they are welded into long bands, the strips are rolled on large reels, which are passed to the pipe machines.

The pipe machine is shown in the accompanying illustration.

The essential features of the pipe machine are a guide-table for the skelp, adjustable to the desired angle; feed-rolls, to pass it forward with an intermittent progress, so that it shall advance when the former is raised and be at rest when it falls; a former, to curve the metal to the desired radius, also adjustable; a furnace, to heat the metal; a hammer, to weld it, and an anvil to support the pipe and receive the shocks of the hammer. No mandrel is used. The pipe in

the forming process is held in place by a pipe-mould, which is a cylindrical shell, within which the pipe rotates as the stock is fed in. The anvil is of considerable mass, steel-faced, and extends the entire width of the skelp. The hammer is light, and at normal speed strikes 350 blows per minute. The heating is done in a furnace so constructed as to heat both the edges to be united for the space of several inches ahead of the point at which the welding is effected. The upper skelp enters the furnace flat, and the lower skelp curved, having already been through the forming-jaws. The heat is imparted by one or two blow-pipes of water gas and air, discharging upon the metal through passages of suitable form in the refractory lining of the furnace. One gas-flame has been found sufficient, but two work better; and besides being more convenient to control, they heat the metal more rapidly and permit an accelerated feed. As very little gas is wasted, the greatest economy attends the most rapid production of pipe, irrespective of the quantity burned, which in any case is about thirty feet per foot of welded seam. The speed of production depends, as stated, upon the thickness of stock to be heated, and the relation of width of skelp to diameter. It averages a foot per minute to each machine, and it is probable this average can be raised considerably. The machines are so nearly automatic in operation that very little skilled labor is needed in running the plant. The operator has his gas, air and feed under control by convenient means, and varies their relations until he has them just as he wants them. He can see the edges as they emerge from the furnace, and about all the skill he needs is that which will enable him to judge by its color whether the iron is above, below or at the welding-heat. Unskilled labor prepares the stock and removes the finished product. The ends of the pipe are cut square by suitable machinery without reversing, and after testing and treating with asphalt, the pipe is ready for shipment. As may be supposed, all the difficulties of mechanical development have centred in the pipe machine. To make this satisfactory in operation has probably been no more serious task than is usually entailed in the effort to make old

mechanical motions perform new functions, but it has consumed a great deal of time and money.

The strengths attainable in light pipe, if the material is used to the best advantage, are quite surprising. A 6-inch pipe, made of No. 14 gauge iron of good average quality, showing under test 33,000 pounds elastic limit, and 50,000 pounds ultimate strength, has a proof strength of 913 pounds per square inch, and an ultimate strength of 1,383 pounds per square inch. A 12-inch pipe of the same stock has a proof strength of 456 pounds, and an ultimate strength of 691 pounds. If a good grade of soft steel is used instead of iron, the 6-inch pipe will carry 1,106 pounds pressure without deformation, and will not burst under 1,800 pounds; the 12-inch pipe can be tested to 475 pounds and will carry 900 pounds without fracture. This is very practical pipe. Using the same diameters and gauges of stock for comparison, we find that the 6-inch spirally-welded pipe weighs 5·2 pounds per foot against 18·77 pounds per foot for standard lap-welded pipe, and 28·28 pounds for medium cast-iron pipe; the 12-inch spirally-welded pipe weighs 10·46 pounds against 54·65 pounds for lap-welded and 77·36 for medium cast iron. I give below tables of strength for steel tubes.

Spirally-Welded Steel Tubes.

Proof strength of stock, 40,000 pounds per square inch.

Ultimate strength of stock, 65,000 pounds per square inch.

Diameter of Pipe.	Gauge.	Proof Strength Per Sq. In.	Ultimate Strength Per Sq. In.
4	18	980	1593
	16	1300	2113
	14	1660	2697
5	18	784	1274
	16	1040	1690
	14	1328	2158
6	18	653	1062
	16	866	1408
	14	1106	1798
8	18	490	796
	16	650	845
	14	830	1079
	12	1090	1771
	10	1340	2177
	8	1650	2681
10	18	392	637
	16	520	845
	14	664	1079
	12	872	1417
	10	1072	1742
	8	1320	2145
12	18	326	531
	16	433	704
	14	474	899
	12	727	1181
	10	893	1451
	8	1100	1788
14	18	280	455
	16	371	603
	14	474	771
	12	623	1012
	10	765	1244
	8	943	1532
16	18	245	398
	16	325	528
	14	415	674
	12	545	886
	10	670	1088
	8	825	1341
18	18	218	354
	16	289	469
	14	369	599
	12	484	787
	10	596	968
	8	733	1192
20	18	196	319
	16	260	422
	14	332	539
	12	436	709
	10	536	871
	8	660	1073
22	18	178	289
	16	236	384
	14	302	490
	12	396	644
	10	487	791
	8	600	975
24	18	163	265
	16	216	352
	14	277	449
	12	363	590
	10	446	726
	8	550	894

Owing to its superior advantages, we shall use steel exclusively in future. It is twenty-five per cent. stronger than good iron, works better and costs less per pound.

The advantages of spirally-welded tubes over any other form of pressure pipes, as regards economy of transportation and handling, are very marked, as will appear from the comparisons of the following table:

COMPARATIVE WEIGHTS OF PIPES, PER LINEAR FOOT, WITHOUT COUPLINGS OR HUBS.

	SPIRALLY-WELDED STEEL OR IRON.						LAP-WELDED IRON.	CAST IRON.		
Diameter of Pipe.	No. 18.	No. 16.	No. 14.	No. 12.	No. 10.	No. 8.	Standard.	⅛ inch Thick.	⅜ inch Thick.	¼ inch Thick.
In.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*				
4	2·06	2·73					10·72	22·05	28·28	34·94
5	2·58	3·42					14·56	26·90	34·34	42·38
6	3·09	4·10	5·20				18·77	31·82	40·56	49·6
8	4·13	5·47	6·98				28·35	41·64	52·68	64·27
10	5·16	6·83	8·72	11·44	14·08		40·64	51·46	65·08	78·90
12	6·18	8·20	10·46	13·74	16·90	20·80	54·65	61·26	77·36	93·7
14	7·22	9·57	12·20	16·02	19·72	24·86		71·07	89·61	108·46
16	8·25	10·93	13·95	18·30	22·54	27·72		80·87	101·82	123·14
								⅝ inch Thick.	¾ inch Thick.	⅞ inch Thick.
18	9·28	12·30	15·69	20·69	25·35	31·19		114·1	137·84	161·9
20		13·66	17·44	22·28	28·16	34·66		126·33	152·53	179·02
22		15·03	19·18	25·27	30·98	38·12		138·6	167·24	196·46
24		16·40	20·92	27·48	33·80	41·60		150·85	181·92	213·28

The question of durability in service is one which naturally suggests itself when light steel or iron pipes are discussed. Experience on the Pacific Coast seems to have settled this question, as the cheap expedients adopted for water-conveyance during the days when hydraulic mining was most extensively conducted have been followed ever since in permanent engineering works. The best attainable data on this subject which I have found, are presented in a paper read by Hamilton Smith, Jr., before the British Iron and Steel Institute, and printed in vol. i. of the *Journal* for 1886. Much of the information contained in this paper is quite surprising, especially in the case of the two mains across Humbug Cañon. These pipes were laid in 1868.

They are of twenty-six inches diameter, 1,194 feet long, of common iron one-sixteenth inch in thickness, single riveted. During all this time they have been delivering water under 120 feet head, and Mr. Smith gives the maximum tensile strain in pounds on the metal per square inch as 11,500, Large as these figures look, they are simply the result of applying to the conditions given in Rankine's well-known formula for their cylindrical shells.

Riveted pipe in its best estate labors under the disadvantage of inherent structural weakness, and liability to rust between the overlapping edges and around the rivets. Pipes of this character on the Pacific Coast are very roughly tarred in position, and the coating is quite liable to be pulled off by the adobe clay in which most of them are laid; but they have a record of useful life since 1853, and many towns are supplied with water under considerable heads from pipes of this kind which have been more than twenty years in service. A welded pipe carefully coated with asphalt should, with fair treatment, have a record at least as good, and probably much better.

The coupling of light pressure pipes involves no difficulties, but it entails new methods. These are convenient and inexpensive, and make perfectly tight joints. The couplings are chiefly of cast iron, and their form depends upon the service in which the pipe is to be employed. Steam, water, petroleum, compressed air and gas, all present different problems in couplings, but no difficulties which have not already been fully met. The couplings are as practical as the pipe. The one generally preferred is the "trumpet flange." The pipe is slipped through the flange, and the projecting end is expanded and laid flat against the face of the flange. The ends of the pipes are thus brought in contact with the gaskets, making perfect joints under all circumstances.

Spirally-welded tubes are adapted for every use calling for pressure pipes. In the paper, before referred to, Mr. Hamilton Smith, Jr., after reciting American engineering experience with light iron tubes, concludes as follows:

"The query presents itself. Why should not wrought

iron or, still better, steel, be used for conduit pipes in preference to cast iron? If it answers the desired purpose in California, why should it not do so in other parts of the world? To one, like myself, who has for years been accustomed to the California practice, it seems as irrational to build a pipe of cast iron carrying water under considerable pressure, as it would be to build a suspension bridge with the supporting chains made of cast iron.

"Experience in the United States has shown that the practicable limit of size for cast-iron mains is a diameter of about four feet, even when the pressure is less than 100 pounds. It is evident that a pipe of wrought iron or mild steel can be safely made of almost any desired size, and this may be of much advantage if it be desired to conduct a large supply of water through pipes for city or other use. For instance, with an inclination of three feet per mile a single pipe eight and one-fourth feet in diameter will carry 280 cubic feet per second, while seven pipes, each four feet in diameter, would be required to transport the same quantity of water with the same inclination. The cost of the large pipe, made of steel or wrought iron, would be considerably less than one-half the cost of the seven small pipes made of cast iron.

"The ideal conduit for high pressures is a welded steel tube; such tubes could probably be subjected to a tensile strain of 25,000 pounds with perfect safety, and would be much preferable to riveted pipe, not only on account of superior strength, but also by reason of almost perfect interior smoothness. * * * The adaptation of a superior and cheap metal, such as mild steel for conduits, will permit the construction of hydraulic works in many parts of the world which now appear to be impracticable, owing to the cost of many of the methods still in use for the transportation of water."

Spirally-welded steel tubes meet all the conditions above described. The industry gives promise of rapid and even phenomenal development, as the cheapness and excellence of the product commands for it instant recognition as the most valuable of recent contributions to engineering materials.

SOME AMERICAN CONTRIBUTIONS TO METEOROLOGY.

By Prof. Wm. M. Davis, of Harvard College.

[*A Lecture delivered before the* Franklin Institute, *November 19, 1888.*]

The lecturer was introduced by Prof. Edwin J. Houston, and spoke as follows:

Members of the Institute, Ladies and Gentlemen:

If our object were to learn the science of meteorology in systematic order, the contributions made to it from our own or from any other single country would form an illogical subject for a lecture; but the fostering of scientific investigation has always been one of the objects of the Franklin Institute, and to this end it may be profitable to review the past as an encouragement to the future; to look over the great contributions that Americans have thus far made to meteorology and thus learn the responsibility for future work that rests upon us. The highly respectable position that we occupy in the history of this science should spur us on to new discoveries.

From the abundance of material, I shall have time to mention only the labors of seven of our meteorologists: Franklin, Redfield, Espy, Tracy, Ferrel, Coffin and Loomis; and in order to give some continuity to the lecture, I shall select chiefly certain suggestions and discoveries made by these eminent men in connection with the irregular disturbances in the atmosphere, known as storms. Many other matters, as well as the labors of Mitchell, Maury, Henry, Blodget, Abbe, and others, must be passed over.

We cannot do better than begin with mention of certain contributions made by the illustrious Franklin. Twenty years before he took his pre-eminent part in our Revolutionary history, he was a leader among the Colonists in several lines

of scientific research, in all of which he showed that keen and critical power which distinguishes the man of high ability. His demonstration of the identity of lightning and electricity is commonly known; it is an extraordinary thing, for since the old days of Jovian thunderbolts, lightning was regarded as outside the ordinary bounds of physical phenomena, and more in the nature of a special creative or rather destructive act. It was as early as 1747 that Franklin conceived the idea that lightning and electricity were identical, but no demonstration of their identity was made until 1752, when a French physicist undertook experiments on the line indicated by Franklin, and drew the electric fluid, as it was then commonly called, down from the clouds. In the same year, but a little later, Franklin performed his extraordinary experiment with a kite, on the outskirts of this city, one of the most daring experiments ever tried; indeed, it proved fatal to a Russian imitator within the year. The result was so decisive that no one has ever questioned it successfully.

Another suggestion from Franklin was that our northeast storms came from the southwest; and with this began the science of weather prediction. Franklin's first mention of this was in a letter to Jared Eliot, dated at Philadelphia, 16th July, 1747. He wrote: "We have frequently along the North American coast storms from the northeast, which blow violently sometimes three or four days. Of these I have had a very singular opinion for some years, viz: that, though the course of the wind is from northeast to southwest, yet the course of the storm is from southwest to northeast; the air is in violent motion in Virginia before it moves in Connecticut, and in Connecticut before it moves at Cape Sable, &c. My reason for this opinion (if the like have not occurred to you) I will give in my next" (Sparks' *Life of Franklin*, vi, 79).

The reasons are stated as follows in a letter to the same correspondent, dated Philadelphia, 13th February 1749–50: "You desire to know my thoughts about the northeast storms beginning to leeward. Some years since, there was an eclipse of the moon at nine o'clock in the evening, which

I intended to observe; but before night a storm blew up at northeast, and continued violent all night and all the next day; the sky thick-clouded, dark and rainy, so that neither moon nor stars could be seen. The storm did great damage all along the coast, for we had accounts of it in the newspapers from Boston, Newport, New York, Maryland and Virginia; but what surprised me was, to find in the Boston newspapers an account of the observation of that eclipse made there; for I thought as the storm came from the northeast, it must have begun sooner at Boston than with us, and consequently have prevented such an observation. I wrote to my brother about it, and he informed me that the eclipse was over there an hour before the storm began. Since which I have made inquiries from time to time of travellers, and observed the accounts in the newspapers from New England, New York, Maryland, Virginia and South Carolina; and I find it to be a constant fact that northeast storms begin to leeward, and are often more violent there than to windward. Thus, the last October storm, which was with you on the 8th, began on the 7th in Virginia and North Carolina, and was most violent there" (*Id.*, vi, 105, 106).

Some writers quote Lewis Evans as the first person to recognize the general movement of our storms. Thus in *Weather Charts and Storm Warnings* (London, 1876, p. 80), Scott says: "The earliest notice of it [the translation of storms] which we can discover is an entry on a map of Virginia, published in 1747 by Lewis Evans, to the effect that all our great storms begin to leeward. Franklin, in 1760, followed in the same strain, but it appears that his attention had been caught at an earlier period, in 1743." Evans was a well-known geographer of the middle of the last century, and his "Map of Pensilvania, New Jersey, New York, and the three Delaware Counties" (1749) was highly esteemed. Following the fashion of those early days, certain parts of the map, of whose topography the author had little information, were occupied with legends explanatory of one matter or another; and among these statements is the following: "All our great Storms begin

to Leeward: thus a NE Storm shall be a Day sooner in Virginia than in Boston. There are generally remarkable changes in the Degree of Heat and Cold at Philadelphia every 3 or 5 Days, but not so often to the Northward. * * * Thunder never happens, but with Meeting of Land and Sea Clouds. The Sea Clouds coming freighted with Electricity, and meeting others less so, the Equilibrium is restored by snaps of Lightning; and the more opposite the Winds, and the larger and compacter the Clouds, the more dreadful are the shocks. The Sea Clouds, thus suddenly bereft of that universal Element of Repellancy, contract, and their Water rushes down in Torrents."

It seems to me very likely if not certain that Evans learned all this from Franklin, and that he wrote it on his map just as he did any other pertinent information that he could gather. The two men were both residents of Philadelphia, and Franklin's letters make such mention of Evans that we may be sure that they knew each other well. Franklin and Hare were publishers in 1755 of a little pamphlet of text that went with a later edition of Evans' map, on which, by the way, the statement about storms quoted above was crowded out by new geographic matter. Evans' statements about thunder-storms bear the clearest witness to Franklin's influence. Writing to Collinson in 1749, Franklin said: "For, if an electrified cloud, coming from the sea, meets in the air a cloud raised from the land and therefore not electrified, the first will flash its fire into the latter, and thereby both clouds shall be made suddenly to deposit water" (*l. c.*, v., 216).

We can hardly suppose that Evans, who nowhere but on the first edition of his map makes mention of the identity of lightning and electricity, was an original investigator in this subject; and as he evidently used Franklin's ideas in this matter, it is likely that he did the same with the northeast storms. I do not say this with any idea of discrediting Evans; he was an able man, as appears from his excellent geographic descriptions, which show an admirable perception of the physical features of our country.

Another of Franklin's letters on this subject was written

in London, in 1760, in which the date of the eclipse of the moon by which his attention was first called to the matter was stated to be on a Friday evening about 9 o'clock some twenty years before. The precise date of the eclipse has been fixed by his great-grandson, Bache, who, taking this letter as his guide, searched out from a list of lunar eclipses the one that occurred at Philadelphia, on a Friday evening, about 9 o'clock, some twenty years before 1760, and found that it must have been in 1743 (JOURNAL FRANKLIN INSTITUTE, xii, 1833, 300). It would seem that both Bache and Scott were not aware that Franklin had written on the subject before 1760.

Franklin's explanation of tornadoes and water-spouts also deserves mention as illustrating the acuteness of his mind. One of his correspondents maintained that water-spouts and tornadoes descended from aloft, a view that still has its advocates, though it seems to me to have no worthy foundation. Franklin knew better, for he said that the indraft which characterizes the surrounding air can have no escape save by ascent. He quotes the case of three whalers lying off Nantucket, and in the centre of the triangle that they formed a water-spout arose. The three whalers, becalmed before, then all caught a breeze and were carried toward the spout. At the spout, the air must therefore ascend. No contradiction has been given to this line of argument to the present day. The evidence generally quoted on the other side is that the funnel cloud, which characterizes the tornado and water-spout alike, descends from the heavy clouds above and strikes the earth or sea. But close observation must show the correctness of Franklin's answer to this. The descent is only apparent; the ascending current is cooled as it enters the rarefied space at the centre of the whirling storm, and its invisible vapor is condensed into visible cloud; as the intensity of the whirl increases toward the ground, the cloud grows in a right line downward faster than its particles are carried in a spiral line upward. Thus a century and a third ago, this ingenious explanation was correctly given for the appearance of descent that has deceived so many observers since then. It is a common thing

to read in accounts of tornadoes that the funnel descended and struck the ground, destroying everything in its path. This is purely a deceptive appearance; there is no descent at all except of the outline of the cloud; the wind is rising all the time as it whirls. Franklin not only clearly perceived this, but he suggested the main cause of the ascent as well. When the lower air is heated, he said, it becomes specifically lighter than the air above, and it is then in an unstable equilibrium; the light lower air will rise through the heavier upper air, if it have opportunity, and in rising it forms a tornado. This is the fundamental idea that still lies at the base of all adequate theories of tornado origin.

The end of the last century and the early years of this one did not witness any notable advances in our science. Our forefathers were otherwise occupied at the time, and may be excused if they found no leisure for the study of the weather.

The fourth decade of this century marks the beginning of a brilliant period. Foremost in the names that then came to notice is that of Redfield. He was a Connecticut Yankee, and when still a young man in 1821 had his attention taken by a great storm that traversed our northeastern states. He found, by comparing notes with several random observers that, while the storm was blowing from the southwest in southern Connecticut, it was blowing from the northeast in the northern part of the state; furthermore, that it appeared sooner in the western part of the state than it did in the eastern, thus unconsciously repeating Franklin's discovery. It flashed on his mind that all this could be accounted for by regarding the storm as a great whirlwind, rotating from right to left around an advancing centre. He mentioned the idea to several friends, but soon dropped it, and thought no more about it till some ten years later his attention was again brought to storms by a severe one that he witnessed in New York, where he was then living, and by which great damage was done to the shipping that sailed to and from that growing port. He recalled the idea

of the whirling storm of ten years before; he looked carefully over all the records that he could procure, and the result left no doubt in his mind. An account of his conclusions was published in *Silliman's Journal* for that year. We must regret his deliberation, for in the ten years that had elapsed since the idea of the whirling storm first took the form in his mind, Dové, a celebrated German meteorologist, had come to a very similar conclusion from his studies of the great European storm of Christmas night, 1821. His account of it was published in 1828. Still earlier, in this century, Colonel Capper, of the East India Company, had come to the same general conclusion, but without stating his evidence in definite terms. And as far back as 1698, an English Captain Langford spoke of the hurricanes of the West Indies as "Whirlwinds." It is somewhat doubtful if he really meant what we do by whirlwinds; he may have used the term as indicating strength, rather than circulation. But although later than all these predecessors, to Redfield belongs the credit of demonstrating what they suggested in more or less vague form. In this he clearly outranks Dové. He must be recognized as the leading original investigator of the subject. His wide grasp of the question is illustrated by the following extracts from his writings.

In his first paper in 1831, he stated that all storms, and not only the violent equinoctial hurricanes, are great whirlwinds or revolving storms, turning from right to left and gradually progressing northeastward; the winds increase in violence toward the centre of the whirl, but at the centre there is commonly a calm; the storms are regarded as gyrating portions of the atmospheric circulation in which they are carried along; and the low barometric pressure at their centre is ascribed to centrifugal force. The practical value of these conclusions in giving means of determining the bearing and probable course of the dangerous storm centre was clearly perceived. The omission of reference to any centripetal acceleration and deflective force, the reference of the origin of the storms to eddies in the trade winds caused by islands or by conflicting winds, and the explana-

tion of the storm clouds and rain by the "depression of the cold stratum of the upper atmosphere," are the chief deficiencies of this most remarkable paper. But far above these omissions stand the correct statements which appear so clearly in this first essay, full-grown.

In 1834, he reached the fine generalization that "there is reason to believe that the great circuits of wind, of which the trade winds form an integral part, are nearly uniform in all the great oceanic basins; and that the course of these circuits and of the stormy gyrations which they contain, is, in the southern hemisphere, in a counter-direction to those north of the equator" (*Amer. Jour. Science*, xxv, 121).

In 1843, Redfield made explicit mention of the law of conservation of areas in accounting for the greater velocity near the centre of the tornado (*Amer. Jour. Science*, xliii, 272), and in 1846, he refers to the same law under another name (equal areas in equal times), to explain the greatly accelerated velocity of rotation in the wind on nearing the axis of a storm (*Hurricanes and Northers*, 87).

Already in 1834, he had ascribed "the ordinary routine of the winds and weather" in the temperate latitudes to the passage of rotary storms, and the irregular variations of the barometer are referred to "the larger atmospheric eddies" (*Amer. Jour. Science*, xxv, 1834, 120, 129). Again, in 1846, the greater variations of winter temperature are shown to result from the passage of rotary storms, with warm southerly winds in their front and cold northerly winds in their rear (*Hurricanes and Northers*, 102). This is the beginning of the understanding of our "cold waves." In all his writings, Redfield seems to have had a thoroughly rational view of the classification of the stormy disturbances of the general circulation. Finally, under the heading, "What are Cyclones?" he wrote in 1854, "The term cyclone was first proposed by Mr. Piddington to designate any considerable extent or area of wind which exhibits a turning or revolving motion, without regard to its varying velocity or to the different names which are often applied to such winds. * * * Thus, all hurricanes or violent storms may perhaps be considered as cyclones or revolving winds.

But it by no means follows that all cyclones are either hurricanes, gales or storms. The word is not designed to express the degree of activity or force which may be manifested in the moving disc or stratum of rotating atmosphere to which it is applied. It often designates light and feeble winds, as well as those which are strong and violent. * * * The more inert and passive cyclones which seldom gain attention, but which constantly occupy in their transit the greater portion of the earth's surface, appear to move in orbits or courses corresponding with those of the more active class which have been traced on the storm charts. * * * In a broad view of the case, the constant occurrence and progression of the cyclones in various degrees of activity constitutes the normal condition of the inferior or wind stratum of the atmosphere, at least in the regions exterior to the trade winds of the globe" (*Amer. Jour. Science*, xviii, 1854, 188, 189). This has always seemed to me a truly sagacious paragraph. The generalizations here announced were overlooked or disputed by many European writers, and were never admitted by Dové, who after making a brilliant beginning as a competitor of Redfield's, afterward failed to keep pace with him on this subject. But Redfield's ideas, although not known as his, gained more and more general currency from the time of the first publication of weather maps in France in 1864, when the essential points of his views as to the cyclonic control of weather were revived and extended by Marié-Davy.

When Redfield began his studies, he said simply that storms were rotary winds, without defining precisely what he meant by that term. The natural meaning of it was that the storm winds ran round in circles. Partly from his own studies, and probably in greater part by reason of the discussions that Espy aroused, Redfield soon made more precise statements in this matter. After the first paper of 1831, in which the diagram showed circular winds, a chart dated 1835, published in 1837, contains diagrams which indicate the spiral course of the winds, now generally recognized, but the text implies only horizontal circuits. In 1839, he wrote, "in the most violent of these storms, it is at

least probable if not certain, that the course of the surface wind is spirally inward, approximating gradually toward the centre of the storm" (xxxv, 204). Finally, in 1846, we come upon the often-quoted passage, here again repeated. "When, in 1830, I first attempted to establish by direct evidence the rotative character of gales or tempests, I had only to encounter the then prevailing idea of a general rectilinear movement in these winds. Hence I have deemed it sufficient to describe the rotation in general terms, not doubting that on different sides of a rotary storm, might be found any course of wind from the rotative to the rectilinear. But I have never been able to conceive that the wind in violent storms moves only in circles. On the contrary, a vertical movement approaching to that which may be seen in all lesser vortices, aërial or aqueous, appears to be an essential element of their violent and long-continued action, of their increased energy toward the centre or axis and of the accompanying rain. In conformity with this view, the storm figure on my chart of the storm of 1830 [to which reference is made above], was directed to be engraved in spiral or involute lines, but this point was yielded for the convenience of the engraver. The common idea of rotation in circles, however, is sufficiently correct for practical purposes and for the construction of diagrams, whether for the use of mariners or for determining between a general rectilinear wind on the one hand or the lately alleged centripetal winds on the other. The degree of vorticular inclination in violent storms must be subject locally to great variations; but it is not probable that on an average of the different sides, it ever comes near to 45° from the tangent to a circle, and that such average inclination ever exceeds two points of the compass, may well be doubted" (*Hurricanes and Norther*s, 1846, 16).

At a little earlier date, he wrote, "In most gales of wind there is, probably, a subordinate motion, inclining gradually downward and inward in the circumjacent air, and in the lower portions of the gale; and a like degree of motion, spirally upward and outward, in the central and higher portions of the storm. This slight vorticular movement is

believed to contribute largely to the clouds and rain which usually accompany a storm or gale, and is probably due, in part, to the excess of external atmospheric pressure on the outward portions of the revolving storm" (*Trans. Amer. Phil. Soc.*, viii, 1843, 79).

The effect of another's teaching is clearly seen here, and to him we now turn our attention.

Contemporary with Redfield was Espy, as original in his line of work, but following very different methods. Espy was a theorizer; his work was largely deductive, and his writings contain continued mention of his theories. His style is positive and aggressive: "I do not submit to authority," he said. Although not always right, he had an extraordinarily clear insight into certain processes which had been but little understood by his predecessors; many of his contributions still hold their place in our science; some have even been independently rediscovered, and have given high credit to their new advocates, after Espy's share in their announcement had been forgotten.

The central idea that dominated all Espy's work was the change of temperature that is produced in the ascending or descending members of a convectional circulation. The idea of convectional circulation had long been stated; we have already met an illustration of it in Franklin's explanation of tornadoes. Espy took this up, enlarged and extended it almost to its modern development. Especially in connection with the changes of temperature in bodies of moist air were his theories of novelty and value; his quantitative estimates of certain processes was exaggerated at first, but approached accuracy later on. He ascribes the beginning of his advance to the time when it occurred to him to calculate the effect which the evolution of latent heat produces during the formation of cloud. "The result was an instantaneous transition from darkness to light. The moment I saw that a rapidly forming cloud is specifically lighter in proportion as it becomes darker, a thousand contradictions vanished,

and numerous facts, 'a rude and undigested mass,' which had been stowed away in the secret recesses of my memory presented themselves spontaneously to my delighted mind, as a harmonious system of fair proportion." This is from the preface of his *Philosophy of Storms* (iv), published in 1841; on the same page he recommends his readers to dwell on the synopsis that follows, it being the essence of his theories, in form prepared for presentation to the British Association the year before.

Many a modern observer of the weather would profit by following this recommendation. Indeed, the statements lately made by Dr. Julius Hann, of Vienna, the leading meteorologist of Europe to-day, is strong testimony to the value of Espy's work; he says: "When several years ago (1881) I first * * * read Espy's works over more carefully, I saw to my astonishment that this eminent meteorologist, who has never been appreciated in proportion to his services, had announced a great number of those principles which we are now accustomed to consider as acquisitions of the so-called modern meteorology; and this not as casual suggestions, which under scientific criticism have hardly any value, but as the results of correct physical theory, tested by observations" (*Meteorol. Zeitschrift*, ii, 1885, 393).

(*To be continued.*)

TECHNICAL ITEMS OF INTEREST.

[*Abstract from the Report of the Secretary, presented at the Annual Meeting of the* INSTITUTE, *held Wednesday, January 16, 1889.*]

MEASURED by the volume of commercial operations, and by the degree of activity that prevailed in nearly all branches of the manufacturing industries, the year 1888 may be reckoned a fairly prosperous one. As compared with the previous two years, however, the figures of production of our iron and steel industries exhibit a decrease, although in the aggregate the volume of production is high, and the fact that our output of coal in 1888 was the largest in our history is satisfactory evidence of general prosperity.

As has been our custom in former annual reviews, we shall rely for the facts and figures respecting the American iron trade, upon data collected and arranged by Mr. Swank, the able statistician of the American Iron and Steel Association, and from the brief summary which he has made public in the Association's *Bulletin*, the following facts and comments are taken.

"The past year has been one of lessened activity in the iron trade of this country as compared with 1887, but if mere production be considered it will be found, with one important exception, to have been fully as active a year as 1886, which was the most productive year in our iron history. Both 1886 and 1887 were booming years for the American iron trade, but the latter was not only more productive than the former, but it was also a more prosperous year.

"Our total production of pig iron in 1886 was 5,683,329 gross tons; in 1887 it was 6,417,148 tons; in 1888 it has been the largest in our history and is probably about 6,500,000 gross tons. A decrease in 1888 was made in the output of Bessemer pig iron. The total production of steel rails in 1888 by the American Bessemer works was 1,528,057 net tons, or 1,364,337 gross tons, against 2,290,197 net tons, or 2,044,819 gross tons, in 1887—a decrease in 1888 of 640,482 gross tons, a shrinkage which is greater than our total production of steel rails in 1879, when 610,682 gross tons were made. The decreased production of 1888, as compared with the production of 1887, was almost exactly thirty-three and one-third per cent. The production in the last half of 1888 was less than in the first half. The consumption of steel rails in 1888 was fully 750,000 gross tons less than in 1887, the imports in 1888 having declined about 77,000 tons as compared with 1887. In 1887 they amounted to 137,588 gross tons, and in 1888 to about 60,000 gross tons.

"In the production of bar iron and plate and sheet iron, and in the aggregate production of cut and wire nails, the figures for 1888 will not vary greatly from those for 1886, while our production of structural iron and steel was greater in 1888 than in 1886 and probably greater than in 1887. This country has in late years developed a large demand for iron and steel for all structural purposes, particularly in the erection of public buildings.

"The consumption of iron and steel in the United States in 1888 was much less than the estimated figures of production which we have given would indicate. While our importations of iron and steel in 1888 were nearly, if not altogether, 950,000 gross tons, they nevertheless fell far below the importations of 1887, which reached the enormous aggregate of 1,783,251 tons. With reduced production and reduced importations of iron and steel, exact figures for neither of which will for some time be accessible, we have estimated from such data as are at hand, that our consumption of pig iron in 1888 has fallen fully 600,000 tons, as compared with 1887, and our consumption of steel rails about 800,000 tons.

"Among the industries which consume iron and steel the building of locomotives and railroad cars of all kinds has been very active all through 1888.

"The principal cause of the decline in prices in 1888, which commenced in 1887, and of the great decline in the production of steel rails, was the reaction in the building of new railroads which set in in 1887.

"Although the manufacturers of structural iron and steel of a few other specialties were fairly prosperous in 1888, it will be seen from the exact figures and the estimates we have given that the year was one of lessened production and exceedingly low prices for our iron and steel manufacturers generally. Take it all in all it was not a prosperous year for the American iron trade."

THE PRODUCTION of Pennsylvania anthracite coal during the past year reached the unparalleled figures of 38,400,000 gross tons, as compared with 34,641,017 tons in 1887, which, up to that time, was the largest output in the history of that important industry. The increase in 1888 was over ten per cent. At the present writing, the exact figures of production of the other varieties of coal are not accessible, but the unusually active condition of manufacturing in the Southern States will certainly more than make up for any falling off in the consumption in other sections, and the figures may be expected to reach 80,000,000 tons. In the figures representing our mineral industries, other than coal and iron, I shall, as heretofore, glean the data from the annual reports of the *Engineering and Mining Journal*, which summarizes the subject in the following terms:

The year just closed has been a very eventful as well as a very prosperous one to the mineral industries. The value of the mineral products, which in 1887 (including coal and iron) amounted to the enormous total of $542,284,225, was still further increased in nearly every item in 1888, when it undoubtedly exceeded $550,000,000, or more than the aggregate value of the mineral products of all European countries.

PRODUCTION.

Iron ore (tons of 2,240 pounds),	11,400,000
Copper. Pounds,	236,000,000
Lead (tons of 2,000 pounds),	189,000
Zinc (tons of 2,000 pounds),	57,000
Silver. Troy ounces,	43,000,000
Coining value, $1 29 per ounce,	$55,470,000
Gold. Troy ounces,	1,650,000
Coining value, $20.67 per ounce,	$34,105,500

AN EXAMINATION of the statistics of railway construction, during the past year, will disclose the explanation of the decided falling off in the output of the Bessemer works. The *Railway Age*, which has excellent facilities for obtaining valuable data on this point, estimates that the railway mileage of the country has increased during the past year by 7,120 miles. While this is much less than the phenomenal increase in the years 1887, 1886, 1882 and 1881, when the new mileage was respectively 13,080, 8,999, 11,568 and 9,796 miles, the record for the past year, nevertheless, exceeds that of every other year in the history of the country, with the further exception of the year 1871, when 7,379 miles were added. As has been the case for several years, Kansas heads the list of states in the amount of new railway constructed within her borders. From the same source above-named, we are informed that in the last three years about 4,400 miles of railway have been built in this single state. Taken by geographical groups, it appears that the twelve states of the Southern group lead with 2,074 miles, or nearly thirty per cent. of the entire new mileage; the ten great Southwestern States and Territories come next with 1,675 miles; the seven Pacific Coast States and Territories show 1,055 miles; the five rich and populous states of the Central Northern group follow close with 1,030 miles; the six immense states and territories of the Northwest add only 834 miles; while all New England and the neighboring Eastern States contribute but 452 miles.

There were obvious signs, toward the close of the year 1887, that the culmination of the period of rapid railway expansion, which began to make itself manifest in 1885, had been reached, and that the year 1888 would exhibit a marked decrease. The fact that the greater portion of the new mileage of 1888 was built in the first half of the year, makes it very evident that much of the work represented the completion of contracts entered into prior to the beginning of the year. The present prospects of the railways are by no means favorable to the investment of capital in the construction of new lines, and we anticipate that the figures for the current year will exhibit a further shrinkage in amount.

IN THE FIELD OF ENGINEERING, the notable event of the past year was the collapse of the Panama Canal project, by reason of the financial failure of the company. This event had long been looked for, and its happening, therefore, was in a measure prepared for, and created, consequently, less disturbance than many anticipated. The failure will undoubtedly cause great distress, and its worst results may not be immediately apparent. What will be the ultimate fate of this ill-considered and wofully-mismanaged enterprise it is at present quite impossible to foresee, since its prosecution by a new management seems to be surrounded by serious complications.

One of the oldest engineering projects in the world is now gradually approaching completion, and the work will probably be finished during the present year. This is the canal through the Isthmus of Corinth, in Greece, to which we have several times made reference in our annual reviews. This

work was first planned some twenty-five years ago, and work was actually begun under the Emperor Nero, so that over 1,700 years will have passed between its beginning and its final completion. As finally excavated, the canal will be four miles long, with a depth of eight metres, or sufficient for the largest vessels which usually navigate the adjacent seas. The total cost of the canal will be about $9,000,000, or $4,000,000 more than the original estimate. The work, it is stated, has been very substantially done, and the cost of maintenance will probably be very light. It has been carried out under the direction of French engineers.

Work on the Manchester Canal, referred to in last year's summary, has been vigorously prosecuted. From the latest accounts of it given in the English technical papers, it appears that there are employed upon it 8,568 men and boys, 51 steam navvies, 98 locomotives, 49 steam cranes, 3,221 wagons, and 104 pumping and other engines.

Work upon the vast structure which will bridge the Firth of Forth is being rapidly pushed, and its completion may shortly be looked for. As this will be by far the largest engineering work of its kind, a specification of its dimensions may not be out of place as a matter of record: The total length of the viaduct will be 8,296 feet, or nearly one and five-eighths miles, and there are two spans of 1,710 feet, two of 680 feet, fifteen of 168 feet girders, four of fifty-seven feet, and three of twenty-five feet, being masonry arches. The clear headway for navigation will be not less than 150 feet for 500 feet in the centre of the 1,710 feet span. The extreme height of the structure will be 361 feet above the extreme depth of foundations, ninety-one feet below the level of the water. The main piers, three in number, consist each of a group of four masonry columns faced by granite 49 feet in diameter at the top, and 36 feet high, which rest either on the solid rock or concrete carried down in some cases by means of caissons of a maximum diameter of 70 feet to the rock or boulder clay, which is almost of equal solidity. The rolling load has been taken as one ton per foot run on each line of rails. The wind pressure provided for is fifty-six pounds per square foot, the total amount on the main spans being estimated at nearly 8,000 tons. The material used throughout is open-hearth or Siemens-Martin steel. The superstructure of the main spans is made up of three enormous double cantilevers resting on the three piers mentioned. Those on the shore side are 1,505 feet, and that on Inchgarvie 1,620 feet in length.

The past year witnessed the actual completion and opening to traffic of the great bridge over the Hudson at Poughkeepsie, certain details respecting which were included in our summary of the events of 1887. The opening of this new highway is regarded as an event of much importance to the transportation interests of the country, since it constitutes the connecting link connecting the railroad systems of New England with those tapping the coal field of Pennsylvania.

An important iron railway bridge, of the Pratt truss type, constructed for the Chicago and Northwestern Railroad, over the Missouri River at Sioux City, was opened for traffic during the past year, making the seventeenth bridge structure crossing this river.

A great scheme for the irrigation of the arid lands of the West, lying between the Rocky Mountains and the Missouri River, has been proposed by Major Powell, Director of the United States Geological Survey. There are several hundred thousand square miles of territory embraced in this region, which are now entirely unfit for cultivation. The plan involves the construction of great dams in the cañons of the rivers of the region at suitable points near the head waters, sufficiently strong to resist the flood waters of spring, behind which vast volumes of water could be impounded, and, by means of aqueducts, canals, etc., etc., distributed over the entire region as it would be needed. All that is needed to render these vast tracts fruitful is the moisture now lacking, and the plan presents magnificent possibilities. The Director believes that, by the intelligent application of his plans, not less than 150,000 square miles of now desert land could be made productive—thus increasing one-third the agricultural land of the country, which at present amounts to 300,000 square miles. Congress has granted an appropriation for the expenses of the preliminary surveys, and the practicability of the project will shortly be determined.

The project for an interoceanic canal across Nicaragua is in the hands of an American company owning valuable concessions from the Central American States, through whose territory the selected route will pass, and the prospects at the present time for the early commencement of the work of construction are good. The surveying expedition sent down during the past year succeeded in locating an exceedingly favorable route, by which the actual amount of canalization will be reduced from forty miles (the estimate of the plan of 1885) to about twenty-eight miles. The company at this writing is awaiting the action of Congress in the matter of its application for a national charter, respecting the grant of which, since no financial support is asked for, there should seem to be no room for objection. The estimated cost of this enterprise is placed at $50,000,000, and the time required for completion five years.

Plans are said to have been perfected for the construction of a great suspension bridge to span the Hudson River from Anthony's Nose (just above Peekskill, and south of the Highlands), on the east, to Fort Clinton on the west bank. The project is said to contemplate a single span of 1,620 feet, and the total length of the structure, including the approaches, will be 2,850 feet. The structure will leave a clear headway for navigation of 163 feet. It will have a double track for railway, and a roadway for vehicles and foot passengers beneath. Like the Poughkeepsie Bridge, this one is projected in the interest of a number of railways, for which it will establish important connections.

IN THE FIELD OF ELECTRICITY, the year just past has witnessed substantial progress in several directions. In electric lighting no remarkable inventions may be noted, and the news of the year may be summed up in the statement that the introduction of the electric systems of lighting con-

tinued steadily, as has been the case for a number of years, until to-day, as one of the electrical journals affirms, it is doubtful whether there is a city of 15,000 inhabitants east of the Mississippi which does not contain an electric lighting station.

In reference to the *telephone*, it may be noted that the long-distance lines have been considerably extended, and that the system has fully established its usefulness, having grown greatly in popular favor. The high quality of work for the proper working of the long-distance lines was signally shown during the time of the great "blizzard" of March, 1888, when they proved to be the only lines that were not disabled by the effects of the storm, and afforded for several days the only means of communication between several of the chief cities of the country, which, but for them, would have been completely cut off from intercourse with the outer world.

In *telegraphy* there is nothing to record of special interest, save, perhaps, the fact that the system of train telegraphy, devised by Phelps, Edison and others, and which was first introduced as a practical working system on the Lehigh Valley Railroad, has fully demonstrated its utility, and is now in daily use on that road.

There has been decided progress in the introduction of electric motive power. This was exhibited not only by the adoption of the electric system for street railways in cities, but in the growing employment of the electric motor for general industrial uses. Specially noteworthy is the favor with which the electric motor has been received in the great mineral regions of our Western country, where it has been applied with most encouraging results to the work of drilling, pumping, transportation, hoisting, etc., in the mines. In many cases, water-power, transmitted electrically over considerable distances, is utilized to operate these motors. The ease with which water-power, otherwise unavailable because of its inaccessibility by other methods, may thus be utilized and transmitted to any desired point within reasonable distances, promises most important practical results. In the development and application of the electric motor, we appear to have made much more progress than has been made in Europe, where comparatively little has been made.

As an item of interest, allusion should be made to the action of the Legislative Commission of the State of New York in recommending that criminals under capital sentence should be put to death by the agency of electricity. This recommendation was duly approved by the law-making powers, and goes into effect from the beginning of the present year. The subject has excited considerable discussion as to whether the direct or the alternating current would answer the purpose most effectively. Thus far there has been no opportunity of testing the question.

In the field of electro-metallurgy there was great activity, and substantial progress in certain directions was shown. The electric-smelting process of the Cowles Brothers has firmly established its value in the metallurgical arts, and, thanks to it, the engineering world is now able to command the valuable alloys of aluminium and silicon at a price low enough to

permit of their extensive employment in the constructive arts. During the past year, a plant for operating the Cowles process on a large scale was completed and put in operation in England.

The Herault process, for producing aluminium alloys by an electrical reduction process, which presents some points of similarity to that of the Cowles Brothers, was put in operation on a commercial scale during the past year in Switzerland. The process in question differs from that of the Cowles in some important details of the apparatus employed, and also, it is affirmed, in respect of the principle of the method itself, though on this last point it would be prudent to suspend judgment. The *rationale* of the operation going on in the Cowles furnace is involved in some doubt, and it cannot be said with certainty whether the reduction of the ores is effected by electrolysis, or simply by the prodigiously high heat generated by the passage of the powerful electric currents through a conducting medium of high resistance; or whether both of these operations are involved. The statement that the Cowles process can be operated as well by an alternating current as by a direct current, has been urged as indicating that electrolysis played, at most, only a subordinate part in the operation; but in the light of recent observations, this argument may prove a fallacious one. The Herault process, however, is strictly an electrolytic one, as will appear from the following concise account: The electric current is employed to fuse the metal with which the aluminium is to be alloyed, and to separate the aluminium by electrolysis of alumina in a molten state. The metal, copper, for the production of aluminium-bronze, is introduced in a divided state into a crucible formed of conducting carbon, suitably strengthened by external casing of metal, this crucible forming the negative pole of the electrolyzing bath, the positive pole being composed of a bundle of carbon plates. After the copper is fused, alumina is introduced into the crucible, where it is fused and electrolyzed, the oxygen passing off at the positive pole, and the aluminium at the negative, and there uniting with the fused copper; the process is thus continuous, the fused alloy being drawn off by means of a plugged hole at the bottom of the crucible, and fresh copper and alumina being introduced by suitable openings in the cover of the crucible as required. This process is said to be operated on a large scale.

Worthy of notice in this place also, is the process of Watt, for refining impure zinc by electrolysis and for reducing the metal from its ores by electrical deposition; and that of Möbius for refining argentiferous matter, which the reader will find fully described in the technical journals.

A most interesting application of electrolysis is the process devised by Elmore, and put in operation last year in England, for the production of copper pipes by electro-deposition. By this process, seamless copper pipes, of any diameter, length and thickness are formed by depositing the metal electrolytically from a bath of acidified sulphate of copper, upon a mandrel. This mandrel is continuously rotated at a uniform rate, and the spongy copper deposited thereon is consolidated by the ingenious expedient of causing a burnisher, formed of a piece of smooth agate, to travel along the entire length of the mandrel backward and forward. By this means, the pipe

formed on the revolving mandrel is quite homogeneous, and the copper of which it is formed exhibits a remarkably uniform tensile strength of about twenty-two and three-fourths tons tensile strength per square inch section, no matter in which direction, longitudinally or transversely to the tube, the test be made. Lately, Mr. Elmore has devised a simple and ingenious method of producing a wire from these electrically-formed tubes, by cutting therefrom spirally, an endless, slender rod of square section, which is drawn down to any desired gauge. The advantage of this method lies in the fact that it avoids the necessity of melting the metal, by which, as electricians are aware, the conductivity of electrically-deposited copper is notably diminished.

Substantial progress was made during the year by the construction of special machines, and by otherwise improving the details of the operation, in adapting the process of welding by electric current, to meet the requirements of practice. Reference is made here to the process and apparatus devised by Prof. Thomson, of which great expectations are entertained.

In the Field of Chemical Technology, perhaps the most interesting event of the year was the establishment and starting in operation, near Birmingham, in England, of a large plant for the commercial production of sodium and aluminium by the process of Castner, which has received frequent notice at our hands, and was referred to in favorable terms in our summary of progress for the previous year. Concerning the success of Mr. Castner's procedure for producing sodium more cheaply than by any process heretofore known and used, there can be no question. The method was exhaustively tested in an experimental works erected for the purpose, and the erection of the Oldbury works followed upon the favorable report of the experts who were engaged to conduct the preliminary examination of its merits. The Oldbury works now comprise a Castner sodium plant of twenty pots, with a maximum capacity of 1,500 pounds of sodium per day; a Weldon chlorine plant for the production of the anhydrous double chloride of sodium and aluminium used for the production of the aluminium metal, comprising twelve furnaces, with a collective capacity of 6,000 pounds of chlorine per day; and a reduction furnace, in which the actual production of the metal is effected. The capacity of the works, when fully in operation, will be, according to published advices, 500 pounds of aluminium metal daily. The product of the works will comprise, also, the alloys of aluminium. The metal is placed on the market at $5 (twenty shillings) per pound—a reduction of nearly one-half upon its present price.

The Oldbury works were formally opened in the summer of 1888, on which occasion, in addition to those immediately interested, many eminent men of science, attracted by the interesting character of the event, were present; and, from the concurrent testimony of the English technical press, the conclusion seems to be warranted that Mr. Castner has met with substantial and deserved success in the introduction of his process on a commercial scale.

The growth of the ammonia soda process, in recent years, has made the

position of the Leblanc soda makers more and more precarious by reason of the severity of its competition, and this fact lends a special importance to every method which promises to introduce economies in the operation of the older process of manufacture, in which an enormous capital is engaged. For these reasons, the chemical world has received with interest the announcement, by Mr. Chance, to the Society of Chemical Industry, of a process for the recovery of sulphur from alkali waste by means of lime-kiln gases, which may take rank as a fundamental improvement of the Leblanc soda process. Mr. Chance claims to recover, either as brimstone or as sulphuric acid, ninety-five per cent. of the sulphur previously wasted in the calcium sulphide of this method of soda making; and as the quantity of pyrites used exclusively for this industry (the sulphur of which is now thrown away) is estimated at 300,000 tons annually, the importance of the new method, should it realize the hopes of its friends, may mean the salvation of the Leblanc process.

A modification of the Weldon process for the manufacture of chlorine, called from the name of its inventor the Weldon-Pechiney process, is attracting attention. It has been introduced at Salindres (France) in an experimental way, with a plant of the capacity of one ton of chlorine per day, and the results may indicate that another pronounced improvement in one of the fundamental chemical industries has been made. For the details of this process, which produces no waste products, and involves the ultimate regeneration of the material (magnesium oxide) employed at the starting point, to serve indefinitely through the same series of operations, the reader is referred to the technical journals.

In metallurgy, a notable event of the past year was the publication of an important paper by Mr. Keep, of Detroit, giving the results of a careful series of experiments upon the influence of additions of aluminium to cast irons, with special reference to the improvement of inferior irons by such additions, so as to adapt them to foundry uses. The results of these investigations appear to establish the fact that small additions of aluminium (in the form of ferro-aluminium), up to one per cent., exert a distinctly favorable influence on cast iron, permitting the production of soft and faultless castings from irons heretofore regarded as altogether unfit for foundry use. Some question has been raised as to whether the results noted by Mr. Keep should not be attributed, at least in part, to the silicon in the aluminium alloy he employed; but the preponderance of evidence appears to be in favor of the view that the influence of small additions of aluminium to cast iron is no less marked and favorable than it is known to be in the case of wrought iron. The interest excited by the announcement of these results is shown by the fact that a considerable demand has lately sprung up for ferro-aluminium for foundry use. Should Mr. Keep's results be verified in practice, they will prove of the highest importance to foundrymen.

It is worthy of notice, in connection with the unusual share of attention that has of late been given to the subject of the cheap production of aluminium, that the general sentiment among metallurgists respecting the practical value of this metal has undergone a considerable modification. Sober

second thought, now that the day of cheap aluminium appears to be drawing nigh, has dispelled many of the extravagant notions that formerly were entertained, even by men of science, respecting the possible utilities of this elusive metal. The more carefully its properties are studied, the more probable does it appear that it will always hold a subordinate place in the arts, and that its greatest utility will be derived from its alloys, which, with diminishing cost of production, will come into very general use in the arts of construction.

The effect of the presence of manganese in steel has been made the subject of careful study, and it is believed that the constructive arts will shortly be the gainers by the possession of a metal possessing altogether new and highly valuable properties. The most interesting results have been obtained with steel containing as much as ten to fourteen per cent. of manganese. It has been found with this material, that notwithstanding its considerable toughness when cast in the ordinary way, an extraordinary gain in strength is obtained by methods, which, in the case of ordinary steel, would cause brittleness, water-cracking, and other defects. The process is termed "water-toughening," and consists in heating the article under treatment to about 1,800° or 2,000° F., and then plunging it into cold water. The nearer the above temperatures are approached, and the colder the water, the tougher will be the material. After water-toughening, notwithstanding their hardness and stiffness, it was found that test specimens could be bent double, cold, almost in the same way as a piece of the mildest forged steel, thus proving that the new alloy combined the apparently contradictory qualities of hardness and toughness. It is believed that manganese steel treated by this toughening process will be found especially well adapted for railway car-wheels, car-couplings and similar uses.

AN INGENIOUS artifice that has lately been successfully put in practice at Shenandoah by the Reading Company, at the Kohinoor colliery, for refilling the excavations from which coal has been taken out, is worthy of mention, since it is desirable that it should be imitated elsewhere throughout the coal regions where similar conditions prevail. The method is both simple and effective, and prevents the caving in of the earth above, and the consequent loss of valuable property, which has not been infrequent in the mining towns of the anthracite region. Besides, the valuable pillars of pure coal, which for many years it was customary to leave in the mines, to prevent falling in of the roof, can now be taken out without fear. A coal dirt conveyer, consisting of a series of semicircular chutes, similar to those used in discharging coal from carts into cellars, and an endless chain with scrapers attached, automatically conveys the fine refuse from the coal breakers to an elevation, from whence it is discharged into a second chute. As the coal dirt falls on this, water, pumped from the mines, mixes with it and carries the stuff, in a semi-liquid state, back through a jig or puddling hole into the bowels of the earth, from whence the coal has been removed. The coal dirt settles to the bottom of the breasts and packs closely, and the water seeks an outlet below, to be

again pumped out to repeat its duty. The cost of this puddling the refuse matter back into the mines, about three to four cents per cubic yard, is very small compared with the value of the pillars of marketable coal of which the mines may be safely "robbed," and the security obtained for dwellings and railroad property on the surface, above the mines. Already more than two acres beneath the city of Shenandoah, from which the coal had been mined, have been again solidly refilled with the coal dirt which used to be piled mountains high around the town.

Public interest was aroused last year to an unusual degree by the announcement that Mr. Edison had succeeded in greatly improving the efficiency of the phonograph. These improvements, it subsequently appeared, consisted in the substitution of a specially prepared sheet of wax, into which the sound record was cut, in place of the strip of tin-foil on which a stylus made the sound record by means of a series of indentations. Other improvements related to the mechanical details of the apparatus. It should be added, however, that the claims of Edison as to priority of invention of the most important element of improvement—that is, the mode of making the sound record—were questioned by Messrs. Bell & Taintor, the inventors of the instrument called the "graphophone."

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, January 15, 1889.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, January 15, 1889.

Mr. H. PEMBERTON, Jr., President, in the Chair.

Members present: Dr. L. B. Hall, Dr. H. W. Jayne, Dr. S. C. Hooker, Dr. Wm. C. Day, Dr. Wm. H. Wahl, Dr. S. P. Sadtler, Prof. Henry Trimble, Dr. H. F. Keller, Messrs. T. C. Palmer, W. L. Rowland, A. T. Eastwick, J. M. Newbold, Prof. R. L. Chase, Dr. Wm. H. Greene, Dr. D. K. Tuttle, and three visitors.

Mr. Pemberton, on taking the Chair, proposed a vote of thanks to the retiring officers for their efficient services.

The Committee on By-Laws reported progress.

The following gentlemen were elected members of the Section: Mr. F. C. Lewin, 1011 Spruce Street, Philadelphia; Mr. C. V. Petraeus, 231 South Front Street, Philadelphia; Mr. R. E. Fisher, 2239 St. Albans Place, Philadelphia; Dr. Wm. H. Greene, 204 North Thirty-sixth Street, Philadelphia; Dr. Geo. A. Koenig, University of Pennsylvania, Philadelphia; Mr. M. Carey Lea, 530 Walnut Street, Philadelphia; Prof. Henry Morton, Stevens Institute, Hoboken, N. J.

The following gentlemen were nominated for membership in the Section: Dr. T. R. Wolf, Newark, Del.; Mr. C. J. Semper, 505 South Forty-first Street, Philadelphia; Mr. S. Lloyd Wiegand, 146 South Sixth Street, Philadelphia; Prof. Edgar F. Smith, Ph.D., University of Pennsylvania; Mr. Marshall R. Pugh, University of Pennsylvania.

Dr. Wahl announced that papers read before the Section could be published in the JOURNAL OF THE FRANKLIN INSTITUTE, simultaneously with other journals, and that such articles would be continuously paged so as to form an independent work, which would be bound and issued as such by the Section.

The matter of obtaining a suitable desk for the benefit of the Secretary of the Section was referred to the conservator with power to act.

Notice was given by the President proposing an amendment to the By-Laws, making the annual dues $2 per year instead of $1 as heretofore.

The President appointed Drs. Greene, Hooker and Hall members of a Committee on Abstracts, the duty of the committee to consist in selecting from the various chemical journals articles to be abstracted, and in assigning such articles to the various members of a volunteer committee, by whom they are to be abstracted for the JOURNAL OF THE INSTITUTE.

Dr. Wahl announced the purchase of a complete set of the *Jahresbericht* for the Library of the INSTITUTE.

Dr. Hooker showed several specimens of the pyrrol, indol and carbazol groups, and spoke briefly on the relations of these compounds to each other. The "fir-wood" reaction was strikingly shown with pyrrol, phenyl-pyrrol and carbazol, and the best way of making it explained. Dr. Hooker called attention to the fact that pine was slowly colored bright green by concentrated hydrochloric acid. This he believed had not been previously observed. A pine splinter, moistened with an alcoholic solution of furfural, was also shown to turn intensely green when exposed to the action of hydrochloric acid gas, but this could be readily distinguished from the action of hydrochloric acid alone.

Adjourned.

WM. C. DAY, *Secretary.*

[*Erratum.*—In list of nominations for membership in December Proceedings, for Henry C., *read*, M. Carey Lea.]

REPORT OF THE CHEMICAL SECTION, FRANKLIN INSTITUTE, 1888.

MR. JOSEPH M. WILSON, PRESIDENT FRANKLIN INSTITUTE:

SIR:—I have the honor to submit the following report of the proceedings of the Chemical Section for the year 1888:

The work of the Section was carried on with the aid of the following

OFFICERS:

President—Mr. J. H. Eastwick.
Vice-Presidents—Prof. S. P. Sadtler, Mr. H. Pemberton, Jr.
Secretary—T. C. Palmer.
Treasurer—Mr. Chas. Bullock.
Conservator—Dr. Wm. H. Wahl.

Stated meetings were held on the second or third Tuesdays of February, May, June, September, October, November and December, and special meetings were held on April 24th and June 4th, making in all nine meetings during the year.

There has been a growing interest in the affairs of the Section on the part of members, and at the present time the indications of future development and increasing usefulness and importance are very marked.

The net increase of membership during the twelve months is nine, making a total of sixty-four members.

Several matters of importance have claimed the attention of the Section during the past year. Three subjects were submitted by the Committee on Science and the Arts, and reported upon by committees of the Section, to wit:

The reopened question of the Hyatt Pure Water Company's filtering apparatus, referred back on account of a protest against the award of the Scott Legacy Medal and Premium thereto; the Sodium Process of Mr. Hamilton Y. Castner, the Hydrogen Process for Preserving Iron and Steel.

These reports were forwarded to the Committee on Science and the Arts, and are now filed among their papers.

The further proceedings of the Section are given in abstract in the following record:

An arrangement has been made, whereby the proceedings of the Section shall be published in full, in successive numbers of the JOURNAL OF THE FRANKLIN INSTITUTE, and the minutes of the December meeting, together with several papers, have already appeared in the previous impression.

ABSTRACT OF PROCEEDINGS, 1888.

Stated Meeting, February 14th.—Dr. E. H. Keiser gave an account of his work on the estimation of the atomic weight of oxygen. The method followed was the burning of hydrogen occluded by palladium, and weighing of resulting water. Results showed $O < 15{\cdot}96$. Adjourned.

Special Meeting, April 24th.—The Treasurer's report for 1887 was read. Bills were ordered to be paid. Resignations of Dr. J. B. Lober and Mr. Bruno Terne were accepted. Nominations of four gentlemen to membership were made. The deferred election of officers took place. The President announced the following committees: (1) *On the Castner Sodium Process*, Dr. E. H. Keiser, Messrs. Weikel and Palmer. (2) *On the Hydrogen Process for Preserving Iron and Steel*, Dr. Wm. C. Day, Messrs. Matos and Chase. Amendments to By-laws were announced. Dr. E. H. Keiser spoke further of his work on the atomic weight of oxygen. Further results had shown the probable correctness of the usually accepted number, 15·96. Adjourned.

Stated Meeting, May 15th.—The resignation as member of the Section of Mr. L. W. Moody was accepted. The committees appointed at last meeting reported progress, and were continued. Mr. Victor de Balas, Dr. D. K. Tuttle, Dr. Samuel C. Hooker, and Mr. Geo. C. Webster were elected to membership. The protest of Prof. A. R. Leeds against the report of a committee of this Section, on the Hyatt Pure Water System, together with said report and correspondence concerning the subject, was read, and, on motion, the matter was made a special order for an appointed meeting of the Section. Adjourned.

Special Meeting, June 4th.—The protest of Prof. A. R. Leeds against the favorable report of the Committee on the Hyatt Pure Water System, was read; also, the report in question, and various letters and documents bearing on the matter. After a very full discussion, it was

Resolved, That the Secretary be instructed to inform the Committee on

Science and the Arts, that the Chemical Section, acting as Committee of the Whole, has carefully considered the protest of Prof. A. R. Leeds against the award of the Scott Legacy Premium and Medal to the Hyatt Pure Water Company, and does not deem the evidence submitted of sufficient importance to warrant it in recommending a re-opening of the question.

Dr. E. H. Keiser read the report of the Committee on the Castner Sodium Process. The report concludes with the following: "It appears, from all the evidence submitted to us, that, through the efforts of Mr. Castner, an advance step has been taken in the manufacture of sodium, which cannot help having a beneficial effect on industry." The report was adopted. Dr. Wm. C. Day read the report of the Committee on the Hydrogen Process for Preserving Iron and Steel. This report contained a description of the process, but stated that the committee had been unable to obtain any evidence of its successful working. Accepted. Adjourned.

Stated Meeting, June 19th.—Bills for printing were ordered to be paid. Dr. H. W. Jayne read a paper on "Coal Tar Products." The paper was illustrated by numerous specimens and drawings. The lecturer spoke particularly of the present state of manufacture and various uses of naphthalin, giving many facts and circumstances of great interest. On motion of Prof. N. W. Thomas, a vote of thanks was tendered Dr. Jayne for his unusually interesting paper. Adjourned.

Stated Meeting, September 18th.—Routine business and general discussion. Adjourned.

Stated Meeting, October 16th.—Dr. Samuel C. Hooker read a paper on "Estimation of Nitrates in Natural Waters, and Some New Reactions of Carbazol." A general discussion of the paper followed. Adjourned.

Stated Meeting, November 20th.—Two gentlemen were nominated for membership in the Section. Treasurer was authorized to receive subscriptions to JOURNALS for the year 1889. Nominations of officers for the year 1889 were made. Mr. H. Pemberton, Jr., spoke of a constant error found by him in a line of burettes made by Greiner, of New York, due to the graduation having been made with the aid of mercury, the meniscus of which is different from that of water. Dr. Jayne described the extensive color works at Basle, and laboratories connected with them; spoke also of the vast extent of the color market in China and Japan, due to the practice of household dyeing. The commercial peculiarities of the color trade of Europe were also described. Miscellaneous discussion. Adjourned.

Stated Meeting, December 18th.—Two gentlemen were elected members of the Section, and seven nominated. The following were elected officers for 1889:

President—Mr. H. Pemberton, Jr., 1947 Locust Street, Philadelphia.

Vice-Presidents—{ Dr. S. C. Hooker, Franklin Sugar Refinery, Phila.
Mr. T. C. Palmer, 22 North Front Street, Philadelphia.

Secretary—Dr. Wm. C. Day, Swarthmore College, Delaware County, Pa.

Treasurer—Dr. H. W. Jayne, Bermuda Street, Frankford, Philadelphia.

Conservator—Dr. Wm. H. Wahl, FRANKLIN INSTITUTE, Philadelphia.

Mr. Pemberton presented a communication from Dr. Wahl, concerning the publishing of papers of the Section. Committee to confer with Dr. Wahl, Mr. Pemberton, Jr., Dr. S. C. Hooker. Committee to revise By-laws and membership list: Mr. T. C. Palmer, Dr. H. W. Jayne, Prof. R. L. Chase. Mr. Luthy exhibited and remarked on the mineral eudialyte. Prof. Chase and Dr. Jayne discussed the film of the Welsbach gas burner. Dr. Hooker showed samples of so-called electrically refined sugar. Mr. Luthy agreed with him in his estimate of the alleged electric process. Mr. Macfarlane exhibited a souvenir of the twenty-fifth anniversary of the color works of Meister, Lucius & Bruening. Dr. Hooker showed a sample of saccharin and described the most reliable test for it. Discussion of the wholesomeness of saccharin, by Dr. Hooker, Dr. Jayne, Dr. Hall. Adjourned.

Respectfully, T. C. PALMER, *Secretary.*

ON THE ASH OF TILLANDSIA USNEOIDES.

BY T. C. PALMER.

[*To be read before the Chemical Section*, FRANKLIN INSTITUTE, *February 19, 1889.*]

At the suggestion of Prof. H. Trimble, I have made an analysis of the ash of Florida long moss, with results that are perhaps worthy of publication.

About the year 1835, Avequin of New Orleans, published* an analysis of this ash, in the following terms:

1,000 grammes of moss gave 32·35 grammes ash.

[Ash = 3·235 per cent.]

Composed of—

	Grammes.
Salts of potash (phosphate, sulphate, carbonate, chloride),	11·47
Lime, partly as carbonate,	5·96
Phosphates of lime and magnesia,	9·26
Silica containing a little iron and manganese,	5·66
	32·35

This seemed to be the only analysis hitherto made of the ash, and it is very incomplete.

The results obtained by me are given as the average of two concurring analyses, and are as follows:

* *Journal de Pharm. et Chim.*, iii., 385, 1835.

Total ash, 2·95 per cent., the dried plant.

PERCENTAGE COMPOSITION.

	Per Cent.
SiO_2,	10·3000
Fe_2O_3,	2·100
Al_2O_3,	2·600
MnO,	1·672
CaO,	12·700
MgO,	11·351
K_2O,	13·759
Na_2O,	14·856
SO_3,	7·419
Cl,	6·947
CO_2,	12·900
P_2O_5,	3·034
Total,	99·638

It is rather difficult to compare these two analyses, on account of the difference in the way they are recorded; but in the two cases where I have tried grouping some of the constituents in the manner of Avequin, the agreement is close enough to show that in all probability, nearly identical results have been reached in the two cases. So far as it goes, this is proof of the *à priori* idea that the ash of this plant is practically, and within certain limits, uniform, regardless of where it grows. Avequin gathered his sample near New Orleans; that selected for the above analyses came from Florida.

It is my desire to point out that here we have an anomaly of a certain sort. *Tillandsia* is a typical epiphyte, and according to definition should select its mineral matter, as well as its organic matter, entirely from the air. Its roots are not supposed to give it any nourishment, being merely anchors or grippers.

But unless the floating dust of the forests where this plant grows is more plentiful and more complicated in composition than we have any reason to think it, what we know of the circumstances of *Tillandsia's* growth points, in the light of these analyses, to an absorption from the trees on which it grows, of the mineral constituents at least. The presence of manganese oxide to the extent of 1·672 per

cent. of the total ash, is especially significant, for manganese has come to be looked on as a very common constituent of vegetable growths in general.* Thus it is found in notable quantities in wheat, edible roots, such as potatoes, in peas and beans, in tobacco, tea, coffee, fruits, etc., and not accidentally, but uniformly. But especially in point is the fact that manganese is very plentiful in the barks of various species of trees. Thus, two samples of the bark of *Quercus tinctoria* gave each a total ash of about three per cent. and of this, in each case, about 1·5 per cent. was manganese oxide. An extract of hemlock bark (*Abies Canadensis*) gave a total ash of 2·5 per cent., of which manganese oxide constituted 5·128 per cent. An extract of quercitron bark gave an ash of 4·98 per cent., of which 3·740 per cent. was manganese oxide. These few examples might be continued indefinitely, but they will suffice to show the abundance of manganese in barks; and, further, its presence in the extracts of the barks shows it to be in a soluble form in the barks. The other constituents are such as one finds in the bark of trees; and no single one of them is entirely anomalous in a plant. So that it would appear that *Tillandsia* does probably get its mineral food like other plants, from the earth and not from the air.

The crucial test, however, remains to be made, and I shall proceed to make it. That will consist in the analysis of some *Tillandsia* that has been grown on a support incapable of affording any mineral matter already in solution, such as a glass rod. Such an analysis will be the subject of another paper.

ABSTRACTS.

ON THE BEHAVIOR OF THE HYDRATES AND THE CARBONATES OF BARIUM AND OF THE ALKALI METALS AT HIGH TEMPERATURES.—By Prof. W. Dittmar (*Jour. Soc. Chem. Ind.*, **7**, 730). A description of the carbonates and hydrates of the above bases when highly heated in an atmosphere of hydrogen, of nitrogen, and of carbon dioxide. *Carbonate of lithia*, heated partly by Bunsen burner, partly by gas blow-pipe, for thirty-seven hours, in atmosphere of *hydrogen*, gave a residue analyzing $Li_2O = 99·57$ per cent., and $CO_2 = 0·6$ per cent., showing practically a complete decom-

* Maumene. *Bull. Soc. Chim. de Paris*, **42**, 305.

position, into oxide, due principally to the action of the hydrogen, but partly to mere dissociation, as the following experiment shows: Li_2CO_3 heated in an atmosphere of *nitrogen* to highest temperature for one hour, gave residue containing 7·77 per cent. Li_2O. Heated in same manner for ten hours, residue contained 30·37 per cent. Li_2O. Even in an atmosphere of carbon dioxide, the Li_2CO_3 was slightly decomposed, showing traces of Li_2O; and this, too, at a temperature barely sufficient to keep the substance in a state of fusion. An interesting result, however, was obtained by heating Li_2CO_3 in CO_2 to a red heat, *under a pressure* varying from one slightly above the normal to a full extra atmosphere (in boat in a porcelain tube). The mean of several closely agreeing experiments gave a residue containing *more* CO_2 than required, if we accept Stas' atomic weight of 7·02; the atomic weight, in fact, so deduced, being 6·900. The Li_2CO_3 used was carefully purified, but the presence of any possible impurities would have had no bearing on the argument, as the effect of such would have been to make less CO_2 present; not more.

Lithium hydrate, crystallized ($LiHO + H_2O$), lost in dry hydrogen all crystal water at 100°; the LiHO remaining undecomposed up to 320°. Heated to redness in H for four hours completely reduced to Li_2O. Crystallized *barium hydrate*, heated in hydrogen to red heat, gave in four hours pure BaO.

Barium carbonate, heated in *hydrogen* two hours by Bunsen burner, then five hours by gas blow-pipe, gave residue containing only 0·1 per cent. CO_2.

2·2168 grammes of the same, strongly heated in muffle in atmosphere of *nitrogen* for one hour, lost only 1·9 m'grs., showing great differences in the behavior in hydrogen and in nitrogen.

Sodium carbonate, heated in hydrogen, loses CO_2, leaving mixture of hydrate and carbonate, the amount of hydrate formed in four hours, by blow-pipe, varying from 11·9 to 20 per cent. Heated two hours in nitrogen residue, contained of sodium monoxide 1·759 per cent., showing slow dissociation at a red heat.

Potassium carbonate gave similar results, but with formation of smaller quantities of hydrate. The same may be said of *rubidium carbonate*. This latter salt was heated for two hours over gas blow-pipe; when the crucible was opened, it was found to be empty, showing the great volatility of Rb_2CO_3. A table of solubilities of lithium hydrate is given; also, a description of modification of Liebig's bulbs, by which loss by splashing is prevented, in passage of a quick stream of CO_2. P.

A NEW PROCESS FOR OBTAINING AMMONIUM CHLORIDE FROM THE NITROGEN OF COAL, COKE, CINDERS AND ORGANIC MATTER GENERALLY. —By Andrew French. (*Jour. Soc. Chem. Ind.*, **7**, 735.) A paper well worthy of attention. A large pile of furnace cinders, containing half-burned coal, and which had been drenched with salt water, caught fire. A stream of waste water from a fume condenser saturated with sulphurous acid was run upon it, and, in a few weeks, the fire extinguished. The interesting result of this was the formation of a large quantity of chloride of ammonium.

"It is no exaggeration to say that the surface of the heap was for the greater part covered with white, sparkling sal ammoniac, as if with snow, and, at one time, a ton at least of that salt might have been collected. In some places there were large cakes of it from an inch to an inch and a-half thick."

On digging into the heap after the fire was extinguished, an abundance of sodium sulphate was found, but scarcely any sodium chloride.

Following the advice of Prof. Dittmar, the author, tried the following experiments:

A sample of similar ashes, drenched with salt water, was burned in a Cornish assay furnace with a supply of steam, SO_2, and a limited amount of air; resulting in the profuse production of NH_4Cl. No NH_4Cl was formed if either the salt, SO_2, or steam was omitted.

Again, the nitrogenous substance was mixed with salt and iron pyrites, and made into a little brick with clay (free from N). This was then heated in a porcelain tube, and steam and air together passed through it. The following are some of the results obtained:

	Pounds NH_4Cl Per Ton.
Black's Slamanan coal,	129·6
Clyde Company's Ell coal,	101·2
Clyde Company's Jewel coal,	138·8
Coal *cinders* (coke),	96·8

Experiments on the large scale were then tried with the spent shale from a mineral oil works, in a small kiln, also with coal in the furnaces of steam boilers, using from five hundredweights to five tons of coal in the various tests, and in all cases a large yield in sal ammoniac was obtained. The author quotes several authorities, showing that the production of ammonium chloride in burning coal mines had been observed more than half a century ago. It was in 1884 that he made the observations above described, but it does not appear from this paper, that any systematic application on an industrial scale has since been made. P.

Double Bromide of Copper and Ammonia in Photography. L. L. de Koninck (*Zeitsch. f. angewandte Chemie*, **88**, 507).—Bromide of copper is sometimes applied for correcting over-exposed plates. It is, however, not easily prepared, and the commercial salt is often insoluble and has not the desired effect. The author, therefore, recommends in its stead the double salt of cupric bromide and ammonium bromide, which is easily obtained in the following manner:

A weighed quantity of copper fragments are introduced into a glass-stoppered bottle and covered with about twice their weight of water. Bromine is then added by degrees under frequent shaking, until all copper is dissolved as well as any white cuprous bromide which first forms, and bromine is present in small excess.

Occasional cooling is advisable in order to prevent loss of bromine. The dark red solution is transferred to a porcelain dish and heated until the small excess of bromine is evaporated. To the remaining solution of cupric bro-

mide a corresponding quantity of ammonium bromide is now added in the relation of 2 mol. NH_2Br to mol. Cu, *i. e.*, 195·5 AmBr for 63·3 Cu or 309 for 100. After filtration the solution is evaporated to crystallize. The crystals are emerald green and well formed. The concentrated solution of this salt is wine red, the dilute like that of most copper salts, faint bluish green. A solution of 1 : 1,000 of this double salt acts with great energy upon photographic silver pictures, an over-exposed picture disappearing within a few moments. O. L.

FILTRATION AND PURIFICATION OF COLLOID PRECIPITATES BY DIFFUSION. E. Bauer (*Chemiker-Zeitung, 1888, 789*) recommends for this purpose a funnel, the lower part of which has been cut off, so that the apex of the paper filter reaches down into a body of water (or other solvent) contained in a beaker. By repeated changing the water and covering the precipitate the latter is finally completely washed. O. L.

A NEW ALKALI PROCESS.—By W. W. Staveley (*Jour. Soc. Chem., Ind.*, **7**, 807). During the last half century many attempts have been made to decompose sulphate of sodium by means of slaked lime. Even in very dilute solutions and under a high pressure, however, only a small proportion of the sodium sulphate can be so decomposed; the reason being the comparatively great solubility of sulphate of lime, in connection with the sparing solubility of calcium hydrate. The author finds, however, that by the addition of *cresol* (C_7H_8O; one of the phenols existing in oils from coal) about ninety-five per cent. of the sodium sulphate is decomposed. Any of the phenoloids may be used, those distilling between 190° and 250° C., however, being most suitable. As a practical illustration of the process, eleven hundredweights of quick-lime are slaked and sufficient water added to make a volume of, say, 400 gallons. When cold, about 430 gallons of distilled phenoloids are added, and the mixture gradually run into, say, 900 gallons of a solution of ninety-five per cent. sodium sulphate, containing about twenty-nine and three-fourths hundredweights of the latter. The mixed solutions are now agitated for several hours, at a temperature of 30° to 40° C. About ninety-five per cent. of the Na_2SO_4 has now been decomposed, with the formation of thirty-two and one-half hundredweights of $CaSO_4$, $2H_2O$. The latter is allowed to settle and the solution of sodium phenolates run off, the calcium sulphate being washed on a filter. The sodium phenolate solution is now treated with carbon dioxide (from furnace fires or from lime-kiln); the phenoloids thereupon are liberated and separate as an oily fluid, floating on the surface of the sodium carbonate solution. They can now be used over again for decomposing a new lot of Na_2SO_4, as before. The Na_2CO_3 solution still contains about one per cent. of its bulk of phenoloids, and, to prevent their being carried off with the steam on evaporation, a little caustic soda is added. The Na_2CO_3 is then, after evaporation, separated as "fished salts," in the usual way, the phenoloids remaining in the red liquor (or rather in what would correspond to the red liquor, as in this case, there are no sulphides present), and are, of course, united with the main quantity

separated previously. The fished salts are calcined as usual and sold as soda ash.

By this process phenoloids are lost, (1) by mechanical adherence to the "fished salts," and (2) by retention in the calcium sulphate precipitate; the latter loss being the more important. The total loss amounts to about twenty gallons of phenoloids per ton of Na_2CO_3 produced. By using oils containing phenoloids, instead of the distilled article, the cost of the phenoloids proper would be about five pence per gallon. The net result of all of which being that about $2 worth of phenoloids must be added afresh for each ton of soda ash made. There appears to be no difficulty in obtaining an abundant supply of the oils at the above figure.

The process is, of course, as applicable to potassium salts as to sodium, and the sulphites may be used, when possible, instead of the sulphates.

The whole idea has been developed so far only on a small scale, but the above paper, in which it is described (of eight pages length), excited much interest. The application of organic compounds to the soda industry is a new departure. P.

On the Molecular Weight of Aluminium Compounds.—Roux and Louise (*Bul Soc. Chim.*, **50**, 497), have determined the vapor densities of aluminium methyl and aluminium ethyl by Victor Meyer's method in an atmosphere of nitrogen. Within 40° of the boiling points of the substances, the densities correspond exactly with the formula Al^2X^6; they then gradually diminish, and the decrease is due to decomposition of the vapors. The fact of decomposition was shown by passing the vapor of aluminium ethyl through a glass tube heated to 380°, the walls of the tube then becoming lined with a deposit of aluminium. By the method of Raoult, ethylene bromide being employed as a solvent, the molecular weights found for the ethyl, propyl and isoamyl compounds of aluminium, correspond with the molecular formula Al^2X^6. W. H. G.

On the Preparation of Concentrated Formic Acid.—M. Maquenne (*Bul. Soc. Chim*, **50**, 662) recommends that dilute formic acid (45–50 per cent.) be concentrated by distillation with an equal weight of concentrated sulphuric acid under reduced pressure. The acid so obtained is about eighty-five per cent. pure; loss three per cent. A second distillation of this product, with half its weight of sulphuric acid, gives an acid of ninety-eight per cent., the loss being six per cent. The temperature must not be raised above 75°, and the quantity of sulphuric acid employed must be less than that which, with the water of the formic acid, would yield the crystallizable hydrate, $H^2SO^4 + H^2O$. The formic acid retained by the sulphuric, and which constitutes the loss, may be recovered by diluting with water and redistilling. W. H. G.

On the Rapid Analysis of Water for Industrial Uses, with a View to its Chemical Purification.—Leo Vignon (*Bul. Soc. Chim.*, **50**, 598) determines the uncombined carbonic acid by a standard solution of calcium hydroxide, so finding the amount of lime necessary to saturate the

fred acid. The quantity of sodium carbonate required to throw down as carbonates the soluble salts of calcium and magnesium is then estimated by the aid of a standard sodium carbonate solution. In each case phenol-phthalein is employed as an indicator. W. H. G.

ON THE DETECTION OF SALICYLIC ACID IN BEER.—H. Elion (*Recueil de Travaux Chimiques*, **7**, 211) recommends that the beer be shaken with two or three times its volume of ether; after separation of the latter liquid it is agitated with a small quantity of slightly alkaline water. If salicylic acid be present in quantities of five to ten grammes per hectolitre, and the operation be performed on 100 cc. of beer, the reaction of salicylic acid with ferric chloride is sufficiently marked in the aqueous liquid after acidifying with hydrochloric acid. If much smaller proportions of the acid be present, the acidified aqueous liquid should be shaken out with ether, and the test made on the dry residue after evaporating the ether. The author also describes a satisfactory method for the estimation of salicylic acid. W. H. G.

POTASSIUM METABISULPHITE.—J. M. Eder (Phot. Corresp., **25**, 416, from *Journ. Soc. Chem. Ind.*). Potassium metabisulphite (K_2SO_3, SO_2) is used in place of sodium-hydrogen-sulphite to preserve pyrogallol solutions. It is prepared by saturating a solution of potassium carbonate with sulphurous anhydride and adding alcohol. The salt separates as a white crystalline powder and is washed with alcohol.

CITRIC ACID IN COW'S MILK.—F. Soxhlet (*Bied. Centr.*, **17**, 787–788). G. T. Haekel has confirmed the existence of citric acid, as calcic citrate, in normal milk. The examination of many samples shows the presence of about 0·1 per cent. citric acid. A good cow yields daily, therefore, as much citric acid as is contained in two or three lemons. S. C. H.

REPORT ON THE CHEMICAL CONSTITUTION OF NATURAL GAS.—F. C. Phillips. (From the *Official Report of the Geological Survey of Pennsylvania*). A number of samples of gas taken from various borings in the oil region consisted essentially of hydrocarbons of the paraffin series, with about nine to fifteen per cent. nitrogen.

Carbon dioxide was present in all the samples in small quantities (fractions of one per cent.), and ammonia, oxygen, sulphuretted hydrogen and hydrogen were found in traces in some instances.

Of the hydrocarbons, methane predominates; numbers of unsaturated series are entirely absent.

One hundred cubic feet of the gas was found to have a heating effect, varying with the different samples, equivalent to from seven to nearly nine pounds of pure charcoal. S. C. H.

THE ABSORPTION OF GASES BY PETROLEUM.—S. Gaiewosz and A. Walfisez. (*Zeitsch. f. Phys. Chem.*, **1**, 70. (From the *Journ. Soc. Chem. Ind.*) The coefficient for the absorption of oxygen and many other gases by

petroleum is much higher than that for water. The authors consider it, therefore, illusory to try to protect liquids from oxidation by covering them with a layer of petroleum.

CONSTITUENTS OF SUGAR CANE.—Winter. (*Zeitsch. f. Zuckerind*, 1888, 780. The author states that levulose is not present in normal ripe sugar cane, and that the leaves, while containing cane sugar and glucose, are also free from levulose. Hence, he concludes that the assumption that cane sugar is formed by the condensation of levulose with glucose is no longer tenable. Other constituents of the cane were also examined. S. C. H.

THE PLASTERING OF WINE IN FRANCE.—Report of the United States Commercial Agent, at Limoges. *Board of Trade Journal*, 1888, 439. The addition of sulphate of lime to wine is known as "plastering." It is said that by this means the fermentation is increased, rendered more rapid and complete, and that the wine, while improved in color, has its keeping properties enhanced. Acid sulphate of potash is thus virtually substituted for the bitartrate of potash. Free sulphuric acid is formed in wines which have been plastered. The Academy of Medicine, at Paris, is now discussing whether the practice is desirable, and what effects the changes induced by the sulphate of lime on the mineral constituents of wine are likely to have upon the health of the consumer. S. C. H.

ON THE OCCURRENCE OF BORIC ACID IN WINE.—Georg Baumert; *Berichte*, **21**, 3,299. The author confirms the observations of Ripper & Soltsien with regard to the occurrence of boric acid in the leaves and wood of the vine; and like these chemists insists that boric acid must in future be regarded as one of the normal constituents of the ash of wine. A large number of wines from San Francisco, Spain, France and Germany were examined. S. C. H.

ON PYRODINE, A NEW ANTIPYRETIC.—J. Dreschfeld. *Medical Chron.*, **9**, 89–99. From the *Journ. of Soc. Chem. Ind.* The active ingredient of pyrodine is acetyl-phenyl-hydrazine $C_6H_5.N_2H_3.C_2H_3O$. It is a white almost tasteless, crystalline substance, possessing more powerful antipyretic properties than either antipyrine, antifebrine or phenacetine. Dose, two to four grains for children; eight to twelve for adults. It should not, as a rule, be given oftener than once in eighteen to twenty-four hours, on account of its toxic properties, but as the temperature is kept low for a longer period than by the use of other substances this is very rarely necessary. S. C. H.

CORRESPONDENCE.

To the Committee on Publications.

GENTLEMEN:—Having observed, in a communication to the *Photographic News*, a criticism of certain claims which I made in a paper read before the FRANKLIN INSTITUTE, in November last [JOURNAL OF THE FRANKLIN INSTITUTE, January, p. 54], I addressed the following reply to the editor of that journal, and would like to have the same published also in the JOURNAL OF THE FRANKLIN INSTITUTE. F. E. IVES.

Mr. C. H. Bothamley, in the *Photographic News*, January 11th, says: "Recently Ives has described a process of heliochromy, of which he says, 'I claimed for this process that unlike any similar process yet suggested, it was based upon a true conception of the nature of light and color-vision, and was a strictly scientific method of accomplishing the object sought after.' Now, as a matter of fact, a strictly scientific process of the same character was described by Dr. Vogel, in 1885. Moreover, Vogel's process does not differ very greatly from the later process of Ives."

By this time, I am well used to having my original inventions and discoveries claimed for others, but I am surprised that so intelligent a writer as Mr. Bothamley should have failed to see at once that there is a very, very great difference between Dr. Vogel's process and my own. It is even somewhat amusing to know that while some are professing not to be able to see any essential difference between my principle and that of Hauron, others may be equally unable to see the difference between it and one that calls for the production of more than twice as many negatives, and in no way, even remotely, suggests my plan of representing most of the primary spectrum colors by color mixtures. I am sure a comparison of the three methods must make it evident to any unprejudiced person that each one is vitally different from either of the others.

Hauron's principle, as nearly as I have been able get at it, was simply that of making sets of heliochromic negatives by exposing sensitive plates through "orange, green and violet glasses," and from these negatives, prints in blue, red and yellow pigments, superimposed on a white surface. Although no approved theory of the nature of light and color-vision warrants such an assumption, Hauron assumed that this method should produce pictures correctly reproducing the light and shade and color of the objects photographed.

Dr. Vogel's principle is stated by Mr. Bothamley, in the *Photographic News*, September 9, 1887, as follows: "Vogel proposes to make a much larger number of images, and to use sensitizers corresponding with every region of the spectrum—for example, napthol blue for red, cyanine for orange, eosine for yellow, safranine for green, and fluorescein for bluish green, the ordinary sensitiveness of the plate being sufficient for blue and violet. In taking the negatives the intensity of the blue and violet must be

reduced by means of a yellow screen. The fragmentary images thus obtained are transferred to stones, and each is printed in a color complementary to that part of the spectrum to which the particular plate was sensitive. This complementary color is found, however, in the dye which is used to sensitize the plate." Mr. Bothamley adds, "it is obvious that the greater the number of spectrum regions represented by separate images in this way, the more accurate will be the reproduction of the different shades and variations of color." In short, Dr. Vogel's principle really calls for a different negative and print for each primary spectrum color, of which there may be said to be either seven or a thousand, although even at the least estimate, which is quite unscientific, the number is already so great as to make the process absolutely unworkable wherever it is necessary to expose all the plates simultaneously, as in landscape photography. It is also certain that no known color-sensitizers will sensitize bromide of silver for such narrow bands of the spectrum exclusively. The process is not scientific, because it is impossible. My own method is perfectly distinct from Hauron's, in that I do not expose sensitive plates through "orange, green and violet glasses," and from Vogel's, in that I do not make separate negatives for each region of the spectrum, but only three, and in such a manner as to secure curves of intensity which correspond to the action of the light rays upon the sets of nerve fibrils which produce color-sensation. This, in fact, is my principle, which is undoubtedly new and true, and is carried out by exposing color-sensitive plates through compound color-screens, which have been adjusted by experiment in photographing the spectrum itself, until they yield negatives having curves of intensity like the curves of a diagram correctly representing the action of the spectrum upon the sets of nerve fibrils in the eye. A knowledge of the true nature of light and color-vision makes it evident that there is no theoretical requirement for more than three negatives, with which accurately to reproduce the color effect of every part of the spectrum, and of every natural color, provided that these negatives are made according to this principle.

BOOK NOTICES.

ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF STEAM ENGINEERING FOR THE YEAR 1888. Government Printing Office, Washington. 1888. pp. 101. 10 plates.

The annual report of Engineer-in-Chief George W. Melville, U.S.N., is one of the most interesting sent out from the Bureau of Steam Engineering for a number of years. The general work of the Bureau is first treated of, showing briefly the work done at the different navy yards and on board each vessel in the naval service. A statement is made of the repairs and work necessary to keep the ships efficient, and of what will be of considerable interest to the public generally, the condition of the machinery for the new vessels. The details of all changes of designs authorized are made matters of public record. Each navy yard is taken up, and a recommendation is

made for the purchase of the machine tools necessary to equip the various shops for the proper handling of heavy work. The questions relating to personnel are presented in such a way, that the necessity for an increase in the engineer force to fulfil the requirements of the new navy cannot be denied. The necessity of properly training enlisted men to perform the duties of the fire room, under the new conditions of forced draft, is strongly set forth, as well as the need of first-class mechanics as machinists, boiler-makers, etc.

It is when it speaks of the experimental work carried on by the Bureau, that the value of the report will be most clearly recognized by the general engineering public. The subjects of the reports of experimental work cover a considerable range, and when it is remembered that they were made by officers temporarily taken from other work, the results show how great an amount of valuable data can be obtained at little expense under efficient direction.

The Chief of Bureau recommends that an experimental board of engineers be appointed to make investigations looking to the increase of efficiency of naval machinery of all kinds. It is to be hoped that this recommendation will be speedily carried out.

While the reports themselves can not be dealt with here, the following list of subjects will show that they are well worth reading:

The Belleville Boiler of the Steam Yacht *Shearwater*.

Tests of an Old and a New Type Herreshoff Boiler.

The Hohenstein Engine and Steam Generator (Naphtha).

Boiler Tests of the U. S. S. *Swatara* (forced draft).

The Trials, with Petroleum as a Fuel, of the Burner of the Petroleum Fuel and Motor Company, fitted to a Locomotive.

Tests of a Thompson and a Tabor Indicator.

Comparative Tests of "Magnolia" Metal and "A" White Brass (Anti-friction Metals).

Tests of Aluminium and Navy Bronzes.

Tests of Navy Bronze and Bronze made by the De-oxidized Metal Company.

H. W. S.

TWENTY YEARS WITH THE INDICATOR. By Thos. Pray, Jr. New York: John Wiley & Sons.

This is an eminently practical work, written by a thoroughly practical man on a subject he fully understands, and is in every way adapted to the wants and understanding of those to whom it is addressed.

It is fully and correctly illustrated, and clearly explains every point in language easily understood by working engineers, carefully avoiding the display of formulas which often obstruct the understanding of other works on the same subject, when read by those not learned in such mysteries, for mysteries they appear to be when out of the hands of men not schooled in the higher academies and colleges.

The examples cited and explained in detail impart a kind of instruction to be had in no other way, and the precautions against mistake, which are a

most important part of the knowledge required to realize the proper information and correct inferences therefrom in using the steam-engine indicator, give it a value that does not appear in any other publication on the subject. Every steam-engine user can profit by its perusal. No person with an extended experience among practical engineers in the use of indicators can fail to realize that it is the work of an author, not only completely conversant with his subject, but also happy in adapting his explanations to the capacity of the readers whom it will most benefit.

Some additional valuable information and recipes are added, and a tabulated showing of areas and diameters of circles, which are useful for reference in computing diagrams. It might probably be improved for the use of many, if a table of multipliers to find the horse-power of piston duty per pound average or mean pressure were added, similar to that published by Paul Stillman, of the Novelty Works, about thirty years since, in which from reference to a side column of diameters of cylinders, combined with a headline of piston speeds per minute, the intersections showed a ready multiplier for ascertaining the horse-power for each pound of average piston pressure. Whilst there are many that would not care for this, there are more who could use it with satisfaction and time saving.

It is due to Mr. Pray to say that his publications on this subject have had great influence in producing the growing appreciation of the steam-engine indicator as a valuable and reliable means of detecting imperfections in the construction and working of steam engines, and in suggesting remedies and opportunities for economy, and this is mainly due to the clear and familiar explanation and understanding of the subject he has imparted to practical engineers and mechanics; in short, it is a work that commends itself to them upon simple inspection as the best extant on the subject.

S. L. W.

THE PRINCIPLES OF THERMODYNAMICS. By Robert Röntgen. Translated by A. Jay Du Bois, Ph.D. Second edition. New York: John Wiley & Sons. 1888. pp. xx and 707.

This second edition is much more satisfactory than the first, for several reasons. In the first place, the attempt to teach thermodynamics, without the aid of calculus, is extremely difficult for the teacher and generally unsatisfactory to the pupil. The present edition contains sufficient calculus to give one a good idea of the general principles underlying the subject. The first edition contained practically none. Another improvement is the addition of the English units. The French system is still retained and the formulæ for English units are also given. The labor of changing quantities from one set of units, to use in a formula whose constants are in another set, makes almost any work of this kind written in French units useless for quick work, and the trouble is only taken a few times and the book is then thrown aside.

Writers often do not realize that books that are to be used as reference books for engineers must be written in the units that the engineer uses, and these are feet and pounds in this country.

There is one other improvement to be noted, and that is the comparatively small number of typographical errors. The first edition was full of mistakes; this one has very few.

The book is divided into two parts. The first part treats of general principles and of hot-air and gas engines. The second part treats of steam and steam engines. The first six chapters in each part will give one a fair idea of the general theory of the subject and can be grasped without any great mental effort. A little calculus even here would save a good many pages of plodding, and to the general body of students would be more satisfactory, and there are very few who would take up a volume of this kind to study it who had not some idea of calculus.

In the first part of the work, immediately following the preliminary chapter is a discussion of the Ericcson hot-air engine, the hot-air engines of Laubereau and Lehman and the gas engines of Otto and Laugen. This part of the work is the same as in the first edition, and is, to a certain extent, ancient history. The indicator is described in the introduction, and the addition of indicator diagrams to the work on the gas engine especially would have made it clearer. A discussion of the gas engines usually found in this country would have been of great value for matters of reference. The naphtha and petroleum engines and ice machines might well have been included in the same part of the work and would have added immensely to its value.

The corresponding portion of the second part treats of surface and jet condensers, areas of safety valves and the injector. One chapter and an appendix is devoted to superheated steam and is all that could be desired. Two chapters are devoted to discussing the more important principles which should govern the construction of the steam engine and to making a set of calculations for the same.

The introduction, consisting of two lectures by Prof. Verdet with notes, occupies ninety-seven pages, which, as the translator says, forms an admirable summary of the whole field, but might well have been omitted. A student could not read them with profit, and the general engineer would not.

The examples for practice which occur at the end of each division of the work, have been increased in number, but the answers given to quite a number of them are incorrect. Tables for saturated steam are given, and for the vapors of ether, acetone, chloroform, chloride of carbon, and bisulphide of carbon.

Taken as a whole, the work is one of the best of its kind in English, and should be in the library of every one desiring a thorough knowledge of the subject. As a reference book it is now in fair shape, the only objection being that it is too large a work for one not a student to read, understand, and be able to use with facility.

H. W. S.

MODERN HELIOGRAPHIC PROCESSES. By Ernst Lietze, M.E. New York: D. Van Nostrand Company. 1888. $3.

This is probably the only work on photography in the English language, which is adapted to the special use of engineers, architects and draughts-

men, who may wish to employ light for copying drawings, engravings and manuscripts. More than thirty processes are given, with specimen prints by eight of them, employing chloride of silver, citrate of iron, bichromate of potash and nitrate of uranium as the sensitive salts. Two chapters are devoted to printing frames and devices and machinery for sensitizing the paper, and one to a table of the chemicals employed, giving their French and German names, molecular weights and molecular formulæ, composition, price and remarks relating to their properties and preparation. The author has tested most of the formulæ which he gives, and fairly states the advantages and disadvantages of the different kinds of processes. The book admirably fulfils its purpose. F. E. I.

SCIENTIFIC NOTES AND COMMENTS.

ENGINEERING.

THE CINCINNATI-COVINGTON RAILWAY BRIDGE.—The long span bridge over the Ohio between Cincinnati and Covington which was opened on Christmas day, 1888, is another of the many triumphs secured by the Phœnix Bridge Company, under difficult circumstances, and shows the great resources and energy of this well-known firm.

In the face of three severe freshets, which caused rises in the Ohio of from twenty-five to twenty-seven feet above the ordinary stage, the company succeeded in erecting this great bridge of nearly a mile in length and weighing about 10,000 tons, in a little more than nine months. The longest span is 550 feet in length by 84 feet in depth at the centre. The adjacent spans are each 490 feet, and these three river spans, with the approaches, make an aggregate of 4,811 feet. During the erection of the Covington span in July and August, the staging was forced down stream about one foot by a flood. On August 26th, the channel span, of which about 700,000 pounds were in place, with its falseworks, was carried away by a large raft of drift. Within four days the work of replacing it was begun, and in five weeks' time the entire staging, two travellers and 1,200 lineal feet of pile protection, were in place, with the iron and steel floor again on the falseworks.

The entire span was rebuilt and erected by October 28th, or nine weeks after work was commenced. Just before the coupling of the last panel, another severe storm raised the water twenty-seven feet, preventing the immediate completion of the north span until December 9th, when the floor work was run out and the entire span, 490 feet long, was coupled up on December 25th, making sixteen working days. But, in this case, by the use of electric lights, the work was prosecuted by night as well as by day.

The Kinzua viaduct, erected by this same company, was regarded at the time as a very remarkable instance of rapid construction, but it is eclipsed by the Cincinnati bridge, both in time and difficulties.* H.

* Abstract from *Engineering News* of January 12, 1889.

Is "DEEP WATER ASSURED" AT GALVESTON?—The Chief of Engineers in reply to an inquiry from Congressman Crain, of Texas, as to the defects of the existing methods of making appropriations for rivers and harbors, and as to the cost of the projected improvements at Galveston and other Texas points, says:

"The Board of Engineers, to which the subject of the improvement of the entrance to Galveston harbor was referred, in a report dated January 21, 1886, estimated the cost of jetties completed to the thirty-foot depth of water outside at $7,000,000, their aggregate length being 54,000 feet. The estimated cost of the jetties out to the crest of the bar, $3,000,000, and that this amount would probably give two-thirds of the depths that jetties carried out to the thirty-foot curves would give. These estimates suppose that the money would be supplied as fast as needed, but, in the opinion of the Board, the depth which the jetties will maintain cannot be stated with precision. The case differs widely from that of the South Pass of the Mississippi, where the scouring current results from the overflow of a large river. At Galveston, before the water can flow out (to produce scour) the tidal basin must be filled from the sea, and the area of the inflow is materially affected by the necessary contraction caused by the construction of the jetties. For this reason the problem is somewhat indeterminate, and it is impossible to foretell with exactness the depth which can be obtained with the works that were projected."

This opinion is a strong confirmation of the position stated in the article on "Jetties for Improving Estuaries," published in the JOURNAL of last April, in which it was said that "Every construction on the bar becomes more or less of an obstruction to the tidal ingress, and consequently neither high jetties nor submerged jetties will satisfy the conditions." Reference was also made to the universal experience with jetties, even where the range of tide is great and ample provision is made for sluicing the relatively short channels, at low water, with unsatisfactory results. In view of these facts, and the uncertainty which our own authorities express as to the probable results, does it not seem unjustifiable and unnecessary to expend so large a sum of money for an experiment which all similar precedents indicate must result in failure?

The best and latest foreign practice in such cases, is not to attempt to remove the bar, or to cut a channel through it, but to construct an outer harbor or a landing pier.

The jetty already built at Galveston has done considerable injury, and a large portion of the present half million appropriation is being expended in protection work. Thus, the engineer in charge says: "We are extending the jetty-work toward the city. The east end of the island is only two or three feet above mean high tide, and is not an effective barrier between the waters of the gulf and bay.

"It is overflowed at every unusually high tide, and deep channels are cut through it during every storm. If this were allowed to remain as it is now, the completion of the jetty-work would retard the exit of the water from the bay, and would eventually lead to the opening of a permanent channel

between the bay and gulf through the east end of the island. In order to prevent this we are extending the jetty * * * along the bay side of the island," etc.*

Thus it is seen that the large bank of sand collected by the single jetty is so great an obstruction to the efflux of the tide as to threaten to cut a new channel between the jetty and the city, and to abandon its present outlet. The same causes would operate to retard the *influx* of the tide were both jetties completed, but to a much greater degree, and the harbor would become useless, unless maintained by dredging. H.

SOME FACTS CONCERNING THE POUGHKEEPSIE BRIDGE OVER THE HUDSON.†—The informal opening of this magnificent bridge, on December 29, 1888, by the passage of a train load of the officials, suggests that a summary of this difficult work should be entered upon the pages of the JOURNAL.

The Legislature of New York passed a bill, in 1871, authorizing its construction, without piers.

Capt. Eads and others advised that a span of 2,600 feet was inexpedient, and the plan was modified to include four piers, not less than 500 feet apart in the clear.

In 1873, the Pennsylvania Railroad Company subscribed $1,100,000, being a controlling interest in the capital, which was $2,000,000. On December 17, 1873, the corner-stone was laid, but it was not until 1876 that the work was actually begun under contract with the American Bridge Company, of Chicago. Three piers were partially built by 1878, when work was again suspended until 1886. At this date the Union Bridge Company undertook the contract to complete the entire structure, and began work in September. The original 525 feet rectangular truss spans were modified by the interpolation of the alternate cantilever spans of 530 feet each.

The total length between anchorages is 3,093 feet 9 inches, and with the approaches 6,767 feet 3 inches. The charter fixed the headway at 130 feet above high water, making the grade of track 212 feet in elevation.

Excavation for piers were begun October 8, 1886.

The bottom for more than 100 feet below high water was found to consist of mud, clay and fine sand, succeeded by coarse sand and gravel to rock at 140 feet depth. "The general design of the pier is a crib and grillage, extending from the gravel to ten feet below high water; on this rests the masonry to thirty feet above," and then a steel tower, 100 feet high, to pedestals of trusses. The cribs are 60 x 100 feet in plan and about 100 feet in height. H.

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* *Galveston Daily News*, Friday, October 19, 1888.

† Condensed from the account, by John F. O'Rourke, as published in the *Transactions Am. Soc. of Civil Engrs.* June, 1888.

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Franklin Institute.

[*Proceedings of the Annual Meeting, held Wednesday, January 16, 1889.*]

HALL OF THE INSTITUTE, PHILADELPHIA, January 16, 1889.

Mr. JOSEPH M. WILSON, President, in the Chair.

Present, 135 members and twenty-six visitors.

The Actuary presented the minutes of the Board of Managers and reported that at the meeting held Wednesday, January 9th, ninety-three persons had been elected to membership.

The following report of the operations of the INSTITUTE, during the year 1888, was presented by the President:

ANNUAL REPORT OF THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE.

(For the year 1888.)

The Board of Managers of the FRANKLIN INSTITUTE of the State of Pennsylvania for the Promotion of the Mechanic Arts, respectfully presents the following report of the operations of the INSTITUTE for the year 1888:

MEMBERS.

Membership at the close of 1887,	2,155	
Number of new members elected, who have paid their dues,	104	
		2,259
Lost by death or resignation,	76	
Dropped for non-payment of dues,	102	
		178
Total membership at close of 1888,		2,081

FINANCIAL STATEMENT.

Receipts:

Balance on hand January 1, 1888,		$1,198 49
Contributions of members,	$5,261 00	
Bloomfield H. Moore Fund in trust,	5,000 00	
Legacy B. H. Bartol, New Building Fund,	5,000 00	
Newbold R. Haines, New Building Fund,	5 00	
Certificates of second-class stock,	10 00	
Fund for completion of serials,	150 00	
Interest on investments,	1,593 02	
Cash from sale of Central R. R. of New Jersey Car Trust certificates,	3,000 00	
Cash from other sources,	8,859 65	
		28,878 67
		$30,077 16

Payments:

Committee on Library,	$1,380 32	
Committee on Instruction,	2,189 95	
Maintenance and repairs to building,	1,803 99	
Salaries and wages,	3,942 00	
Insurance,	300 00	
Fund for completion of serials,	1,242 80	
Temporary loan,	1,000 00	
Interest on temporary loan,	152 22	
Other expenditures,	6,648 39	
		$18,659 67
Balance on hand, December 31, 1888,		$11,417 49
Remaining to be paid on temporary loan,		2,000 00

The financial statement makes a better showing than it did last year, on account of the contributions from members being larger—although the deficiency for the year in expenditures over receipts is considerable, notwithstanding the balance on hand shows a little greater at the end of the year than it was at the beginning.

LIBRARY.

The Library has been increased during the year by 3,930 bound and unbound volumes and pamphlets. Under the direction of the Library Committee, a thorough verification of the contents of the Library has been made, which has long been needed. A new system of rules, regulating the use of the Library by non-members, has been put in operation, with satisfactory results. During the year, the Endowment Fund of the Library has been increased by the gift of an additional sum of $5,000 to the Bloomfield H. Moore Memorial Fund, by Mrs. Clara Jessup Bloomfield Moore.

For additional details of the condition and operations of the Library, the members are referred by the Board to the report of the Committee on Library.

THE JOURNAL.

The Board refers to the JOURNAL with satisfaction, since, in addition to maintaining its excellent scientific reputation, it has continued to be self-supporting. The publication of the Index to the first 110 volumes, which was decided upon last year, has been steadily proceeded with, and at the present time is so well advanced that its early completion may be announced. As this work, which is quite onerous, has been voluntarily assumed by the officers of the INSTITUTE, and must be taken up at times when it does not interfere with their regular duties, the delay in its completion will be understood.

The Board would again commend the JOURNAL to the attention of the members and others, as worthy of a more generous support than it receives.

LECTURES.

The smallness of the appropriation made to the Committee on Instruction for lectures during the past year, rendered it necessary to cut down the number

of the lectures, in order to reduce expenses. The Committee has succeeded, however, as heretofore, in securing the services of a number of eminent men to lecture without compensation, and its efforts to maintain the high scientific character of the work done in this field deserve commendation. Many of these lectures, subsequent to their delivery, appeared in the JOURNAL.

During the past year the following lectures were delivered, viz:

January 6. Dr. C. B. Dudley, *one*, on "Fuel Oil."
January 9. Prof. C. Hanford Henderson, *one*, on "Aluminium."
January 13. Commander Allan D. Brown, U.S.N., *one*, on "The Electric Distribution of Time."
January 16. Mrs. R. H. Richards, *one*, on "Sanitary Science in the Home."
January 20. Prof. Wm. D. Marks, *one*, on "The Duration of Incandescent Electric Lamps."
January 23. Prof. Chas. R. Cross, *one*, on "The Determination and History of Musical Pitch."
January 27. Mr. Everett Hayden, *one*, on "The Pilot Chart of the North Atlantic issued by the U. S. Hydrographic Office."
January 30. Mr. John E. Sweet, *one*, on "Machine Designing."
February 3. Hon. Edward Atkinson, *one*, on "The Growth of Manufactures in the United States."
February 6. Mr. Alex. E. Outerbridge, Jr., *one*, on "The Relation Between the Physical Properties and Chemical Constituents of Cast Iron."
February 10. Mr. Wm. Kent, M.E., *one*, on "Weighing Machines."
February 13. Mr. Edward Weston, *one*, on "Electro-Metallurgy."
February 17. Mr. E. A. Gieseler, *one*, on "Standard Measures."
February 27. Mr. Fred. E. Ives, *one*, on "Some Recent Advances in Photography."
N'v'mb'r 5. Prof. Lewis M. Haupt, *one*, on "The Feasibility of Underground Railroads in Philadelphia."
N'v'mb'r 12. Frank J. Sprague, *one*, on "Long Distance Transmission of Power by Electricity."
N'v'mb'r 19. Prof. William M. Davis, *one*, on "Some American Contributions to Meteorology."
D'c'mb'r 3. Dr. Persifor Frazer, *one*, "Introductory to the Course on Chemistry."
D'c'mb'r 17. Dr. T. Sterry Hunt, *one*, on "Some New Points in Chemical Theory."
D'c'mb'r 27. A Christmas Lecture for the Children, by Dr. Persifor Frazer.

At the present time, thanks to the liberality of certain interested members, the Committee has been enabled to introduce the feature of a series of illustrated popular lectures on scientific subjects, for the benefit of the employés of the various manufacturing establishments, and of the members of the several trades. These lectures, thus far, have been well attended, and it is hoped will not only prove useful to those for whose benefit they have been arranged,

but will contribute also to the popularization of the educational work of the INSTITUTE.

DRAWING SCHOOL.

The Drawing School continues under the same management, which has brought it into a condition of high efficiency; and the Board expresses its satisfaction with the character of the work done by the director and his assistants.

The attendance during the spring of 1888 was, ...	203
And for the Autumn Term, ...	179
Total attendance for the year, ...	382

These figures exhibit a slight falling off as compared with those of the preceding year; but there is no question that, with increased accommodations in a new and larger building, the size and efficiency of the school can be much augmented.

COMMITTEE ON SCIENCE AND THE ARTS.

The reorganization of this Committee, which was effected in 1887, has proved of substantial benefit, as is demonstrated by the greater efficiency and steady improvement of its work. The Committee, during the past year, has examined and reported upon thirteen applications, and has now thirty-seven cases under consideration. In one case, the Committee awarded the Elliott Cresson Medal, and in six cases recommended to the Board of City Trusts the award of the Scott Legacy Premium and Medal. The Committee issued during the year a circular-letter, calling to the attention of inventors and discoverers the fact that the Committee was empowered to award or to recommend the award of the Cresson and Scott Medals, under the impression that by this means only could the fact be properly brought to the knowledge of many deserving persons. This circular-letter was widely published in the technical and scientific press, and has had the result of bringing many meritorious subjects to the Committee for consideration.

SECTIONS.

The Chemical Section largely increased its membership during the year, and its work exhibits a most gratifying condition of activity.

During the past year, the Electrical Section was disbanded.

STATE WEATHER SERVICE.

The conduct of the business of the State Weather Service was continued during the past year under the general direction of the Committee on Meteorology, and the service is apparently in a satisfactory condition of efficiency. The publications of the Committee appear regularly in the JOURNAL, and its annual report appears in the Annual Report of the Secretary of Internal Affairs of the Commonwealth.

REORGANIZATION AND FUTURE WORK.

A most encouraging feature in the prosperity of the INSTITUTE has been the substantial increase in the number of its members, and the work is still

going on. The move in this direction was started in October, under a resolution appointing a committee for increase in the membership. This Committee is well organized, and great credit is due to the gentlemen who compose it, for the energy and good work they have shown.

A few months after the founding of the INSTITUTE, the membership amounted to over 1,600. Comparing the present size of Philadelphia with what it was at that time, it is very evident that there should be a very much larger membership than the books have shown for some years back. The ease with which the present increase has been made, only shows what can be done with a little exertion. Some of the new members have been particularly active in this work. There are very many who would gladly join us, if the subject were only brought to their attention, and the objects of the INSTITUTE fully explained to them. The annual income from members is what we must depend upon, to keep up the efficiency of the INSTITUTE; and what we want now, is the addition of about 1,000 or 1,500 members. With a little energy and enthusiasm among those now connected with us, it can be done.

The Committee on Reorganization has taken up the question of subscriptions to the Building Fund, and it is hoped that, in a very short time, the arrangements will be perfected, and the work of actively soliciting subscriptions toward this object will go on. In regard to the wants of the INSTITUTE in this direction, what was said in the last report can only be repeated—the great need of room in the present building, the lack of convenience in the educational departments, an increase of space for the Library, protection from fire, and a better location. Increase in membership will produce the wanted annual income; subscriptions to the Building Fund will give the needed buildings.

Meanwhile, the quiet work of the INSTITUTE goes on; merchants, manufacturers, builders and all the trades are profiting by what it does. But, like still waters running deep, it does not make itself conspicuous in this work before the world, and does not receive the substantial encouragement it needs. Perhaps some exertion on the part of its members may accomplish this last

By order of the Board. JOSEPH M. WILSON, *President.*

REPORT OF THE COMMITTEE ON THE LIBRARY.

The Committee on the Library respectfully reports that during the year 1888 there have been added to the library:

Volumes bound,	1,574
Volumes unbound,	563
Pamphlets,	1,431
Total,	3,568
Maps, charts, etc.,	362
Total number of volumes in the Library, December 31, 1888, bound and unbound, as ascertained by a verification of the catalogue, made this year, and exclusive of all pamphlets,	31,762

In addition to the above the Library contains 18,398 pamphlets, of which—

7,796 are arranged in the pamphlet collection,
2,748 are in the memorial library,
4,185 are in the various departments of the Library,
3,996 remain yet unclassified.

The loose maps and charts number	872
Miscellaneous designs and drawings, ...	578
Lithographs and photographs, ...	1,019

The collection of duplicates at the close of 1888, not enumerated in the above, contained

Volumes bound and unbound, ...		2,232
Pamphlets, ...		4,854
Periodicals, ...		5,759
Maps and charts, ...		155
During the year duplicates have been disposed of to the value of, ...	$167 28	
And books received to the value of, ...	127 95	
Leaving to the credit of the exchange account,	$39 33	

SERIALS.—During the year thirty-nine serials have been completed; some of them difficult to obtain, and all of much value to the library.

The addition of $5,000 to the former gift of $10,000, by Mrs. Clara J. Moore, constituting the Bloomfield H. Moore Memorial Fund, the interest of which sum is for the use of the Library, will be judiciously used by the Committee in furtherance of the design of the donor. The books purchased with this fund are all appropriately labelled, and a record of the title and cost of each volume made in a book kept for that purpose.

The rules of the Committee requiring non-members of the INSTITUTE to receipt for books consulted, was enforced during eleven months of the past year. The number of these receipts filed was 1,449.

CHARLES BULLOCK,
Chairman of Committee on the Library.

The CHEMICAL SECTION submitted the report of its operations during the year, which will be found in the Proceedings of the Section, page 127.

The foregoing reports were severally accepted.

The Secretary presented the following resolution, adopted by the Committee on Science and the Arts, at the stated meeting, held Wednesday December 5, 1888, viz:

Resolved, That the Committee on Science and the Arts, to which was referred the communication of Mr. W. E. LOCKWOOD, respectfully recommends that the INSTITUTE shall construct and take charge of the dynamometer and appurtenances for making tests of the quantity of the hammer-

blow of locomotive driving wheels, in accordance with the plans suggested by the joint committee of the American Railway Master Mechanics' Association and the FRANKLIN INSTITUTE, and that the INSTITUTE shall render all the aid in its power to make the said tests and to report upon the same; *provided*, that the INSTITUTE shall not be at any expense in the matter.

The resolution was approved.

Mr. J. C. BAYLES, of New York, gave an oral description of the process and apparatus devised and used in the manufacture of "Spiral Weld Steel Tubes," illustrating his remarks by a view of the machine employed for the purpose and of an exhibition of a specimen of the product. (Mr. BAYLES' remarks will be prepared for publication.)

Mr. S. LLOYD WIEGAND spoke in terms of high praise of the ingenuity of the process, and of the value of the product, and moved the reference of the subject to the Committee on Science and the Arts for investigation. The motion was carried.

Prof. C. HERSCHEL KOYL, of Sharon Hill, Pa., by invitation, made an exhibition, with a full-size model, of the operation of the Parabolic Semaphore invented by him, and which formed the subject of a paper at the stated meeting of the INSTITUTE held in November last.

The Secretary presented his annual report, an abstract of which appears in this impression of the JOURNAL.

The result of the annual election, held this day, resulted in the choice of the following gentlemen:

For *President* (to serve one year), ... JOSEPH M. WILSON.
For *Vice-President* (to serve three years), . . FREDERICK GRAFF.
For *Secretary* (to serve one year), ... WILLIAM H. WAHL.
For *Treasurer* (to serve one year), ... SAMUEL SARTAIN.
For *Auditor* (to serve three years), . . . WILLIAM A. CHEYNEY.

For *Managers* (to serve three years):

GEORGE V. CRESSON,	JOHN LUCAS,
PERSIFOR FRAZER,	SAMUEL P. SADTLER,
EDWIN J. HOUSTON,	WM. H. THORNE,
ENOCH LEWIS,	JOHN J. WEAVER.

For *Members of the Committee on Science and the Arts* (to serve three years):

L. L. CHENEY,	SAMUEL R. MARSHALL,	CHAS. E. RONALDSON,
L. D'AURIA,	WM. MCDEVITT,	SAMUEL SARTAIN,
J. L. GILL, JR.,	J. R. MCFETRIDGE,	CHAS. A. RUTTER,
F. LECLERE,	A. E. OUTERBRIDGE, JR.,	S. LLOYD WIEGAND,
W. B. LEVAN,	GEO. H. PERKINS,	CARL HERING.

Mr. H. R. HEYL offered the following amendments to the By-Laws, which had been duly posted:

PROPOSED AMENDMENTS TO THE BY-LAWS.

ARTICLE IV.—PAYMENTS.

"SECTION 1.—Every member, other than a holder of second-class stock, shall pay an annual contribution of five dollars, but the payment of one hundred dollars within any one year shall constitute a member for life, with an exemption from all annual payments.

"SEC. 2.—All sums of money received from life memberships shall be placed in the Permanent Endowment Fund, the income from which only shall be available for the general purposes of the INSTITUTE.

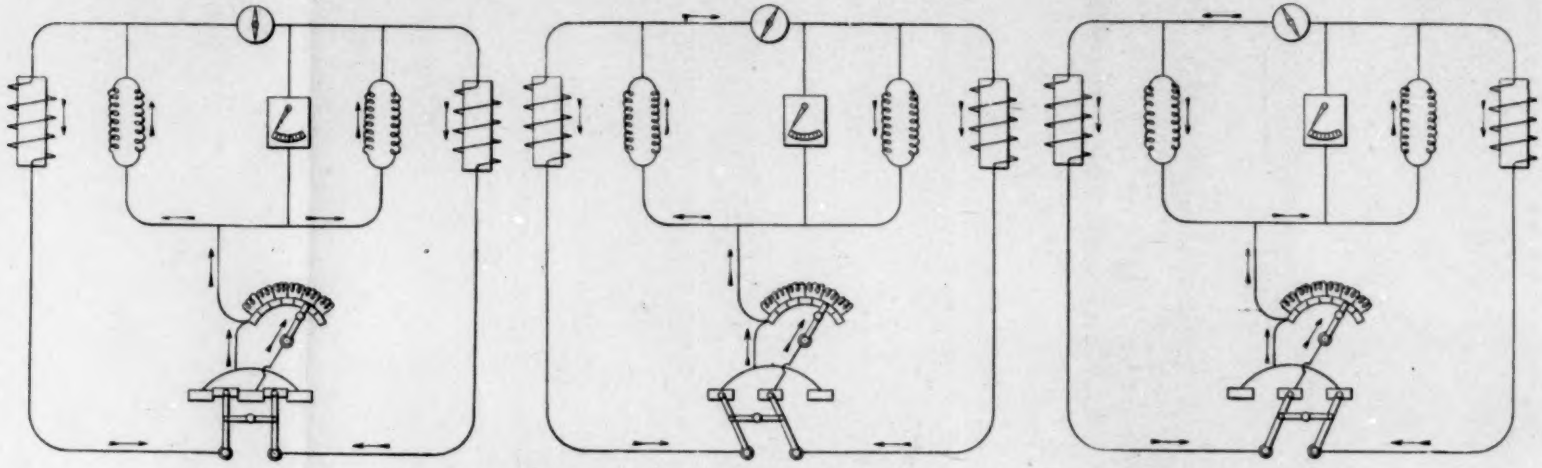
"SEC. 3.—Stock of the second-class may be held in trust for persons not of legal age, and shall be liable to the payment of only one-half the annual fees due upon stock of second-class held by persons of legal age; provided, that when such minors arrive at legal age, new certificates, subject to the full annual contribution, shall issue on payment of the customary fee.

"SEC. 4.—The annual payments of fees for membership shall be due and payable on the 1st of October in each year, in advance; but all members elected after the 31st of January in each year shall pay, in advance, at the rate of *fifty cents* a month to the 1st of October next ensuing."

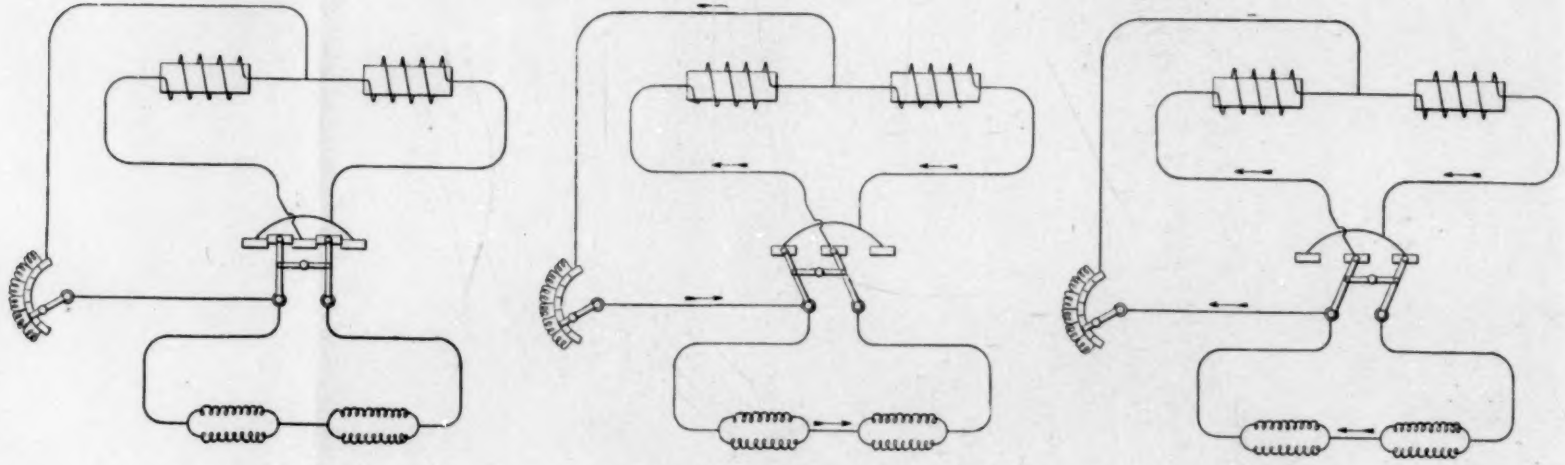
A motion to publish the same in the daily papers was voted down.

Adjourned.

WM. H. WAHL, *Secretary.*



First Diagram—Shunt Machines.



Second Diagram—Series Machines.